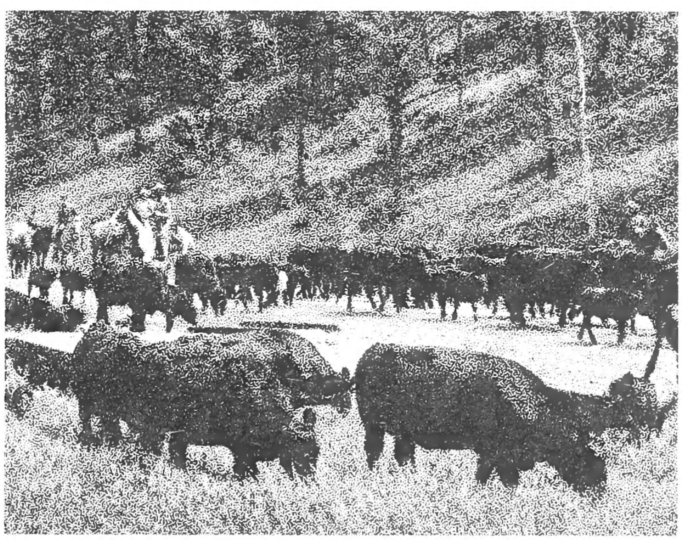
United States Department of Agriculture

Forest Service

Forest Resource Report No. 22

An Assessment of the Forest and Range Land Situation in the United States



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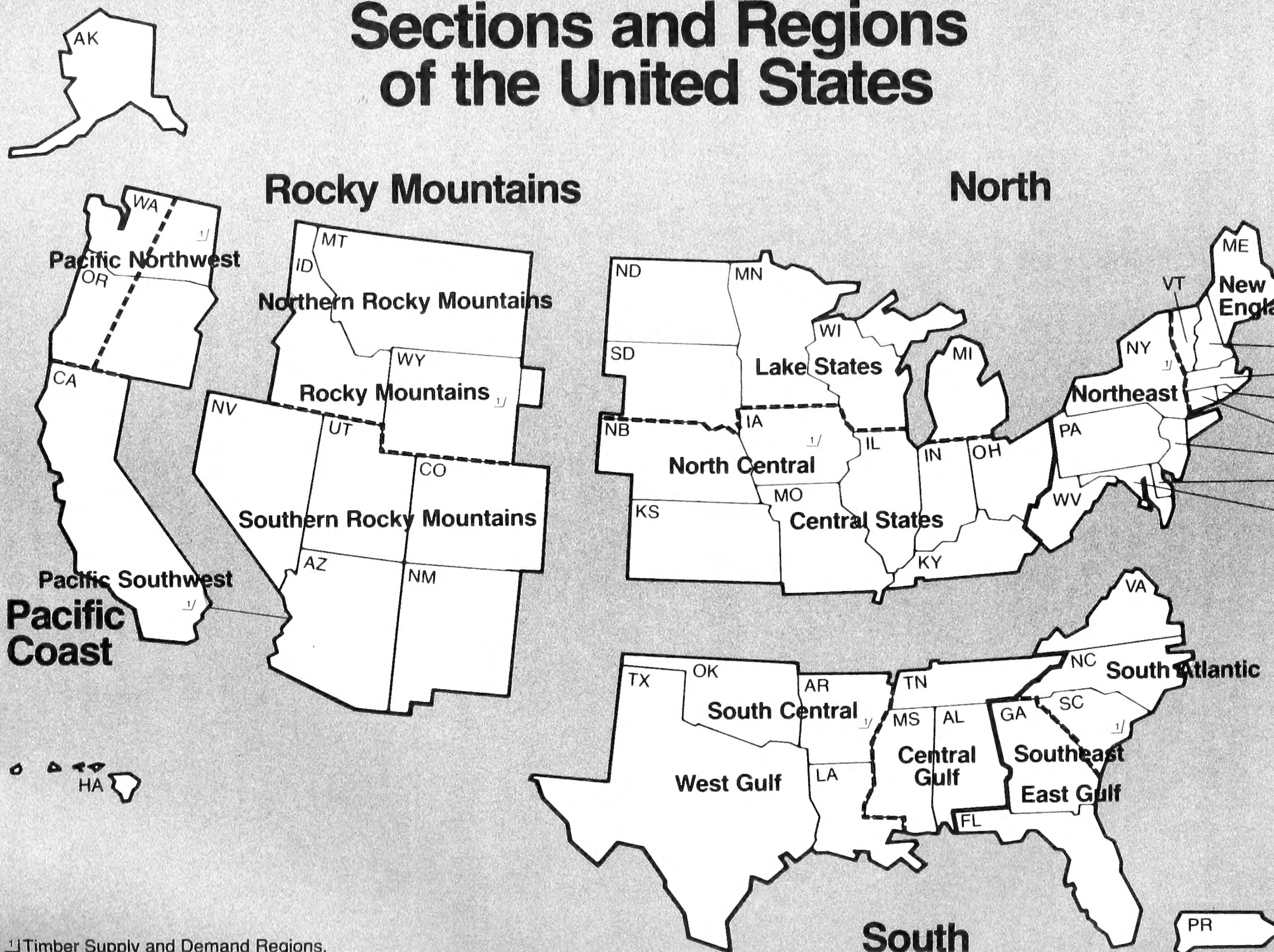
Sections and Regions of the United States



1/ Timber Supply and Demand Regions.

An Assessment of the Forest and Range Land Situation in the United States

Prepared by the Forest Service,
U.S. Department of Agriculture, for submission to Congress as required by the Forest and Rangeland Renewable Resources Planning Act as amended by the National Forest Management Act of 1976

Forest
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Report
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Foreword

This Assessment, the second comprehensive study of the renewable resources of forest and range land and the associated waters, has been prepared in response to provisions of the Forest and Rangeland Renewable Resources Planning Act of 1974 as amended by the National Forest Management Act of 1976. It shows that the Nation's demands for outdoor recreation, wildlife and fish, range grazing, timber, and water have been growing rapidly. It also shows that, in response to increases in population, economic activity, and income, demands for these products will continue to rise in the decades ahead.

Although projected growth in demand differs for the various products, the increases are much above the levels that can be supplied with present management programs and existing physical facilities. Thus, we are faced with a future of intensifying competition for the available supplies of renewable resource products, and the resulting and adverse impacts on the economy, the natural environment, and the general quality of life.

This outlook can be changed. There are many opportunities on the 1.7 billion acres of forest and range land and associated waters to increase and extend supplies of nearly all renewable resource products. For example, these lands and waters have the physical capacity to supply sites for most types of outdoor recreation well in excess of expected increases in demand and to support much larger numbers of most species of wildlife and fish. Under intensive management, the forest and range lands have the capability of producing nearly three times the volume of forage and in time more than twice the volume of timber grown today.

With proper management, the increased levels of output can be maintained for the benefit of future generations. In appraising the need for action, this is a major consideration. In the long run, with growing pressure on the environment and nonrenewable stocks of ores and fuels, renewable resources will surely become increasingly important to our economy and society.

R. Max Peterson
Chief

Acknowledgments

Many members of the Forest Service, other Federal agencies, State agencies, universities, and conservation and industrial organizations have contributed to this study. The names of the principal authors and contributors to the individual chapters are listed below.[1] The help of all others who compiled material or contributed in other ways is also gratefully acknowledged.

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The principal authors of Chapter 2, Forest and Range Lands, were Thomas E. Hamilton and Daniel D. Oswald. Other substantive contributors included Lee J. Bardwell and Brian R. Wall — land use trends; Dwane D. Van Hooser — forest land; Jack E. Schmautz — rangeland, Kermit N. Larson — regional overviews; Neal P. Kingsley — North; Paul A. Murphy — South; Alan W. Green — Rocky Mountains and Great Plains; Charles L. Bolsinger — Pacific Coast; Howard E. Banta — minerals; Elwood L. Shafer — urban forests; Neil Paulson and Leon S. Dochinger — air.

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[1] Contributors are members of the Forest Service unless otherwise noted.

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Dwight Hair was the study manager and contributed in various ways to the preparation of the report. J. Lamar Beasley, Perry R. Hagenstein (New England Natural Resources Center), Max A. Davidson, and Susan J. Branham also made significant general contributions.

The hundreds of reviewers of the draft of this Assessment have also contributed in substantive ways. Their suggestions and comments have been especially helpful in preparing this final draft, and they are gratefully acknowledged.

The detailed comments of John Fedkiw (Office of Budget Planning and Evaluation) and his consultations with the principal authors and managers deserve specific recognition. These have led to significant improvements in the analyses and the presentation of results.

Preface

Most decisions on the management of forest and range lands and the associated waters have long-term impacts on renewable resources and, in a broader sense, on the economy, the society, and the natural environment. As a matter of common sense, it is desirable to base these decisions on factual and objective analyses of the present and prospective renewable resource situation.

The need for such analyses has long been recognized by Congress and by others interested in the administration, management, and use of the Nation's forest lands. Congressional interest was first expressed in the Appropriations Act of August 15, 1876, which appropriated $2,000 for the employment of an expert to study and report upon forest conditions.[1] Other Congressional directives followed for forestry or timber studies on an as-needed basis. In 1927 the McSweeney-McNary Act directed the Secretary of Agriculture to assess, on a continuing basis, the forest situation in the United States.[2] The assessment provision of this Act was amended and broadened to include rangelands[3] by the Renewable Resources Planning Act of 1974 as amended by the National Forest Management Act of 1976. Under this legislation, the Secretary of Agriculture is directed to:[4]

> "... prepare a Renewable Resource Assessment ... the Assessment shall be prepared not later than December 31, 1975, and shall be updated during 1979 and each tenth year thereafter, and shall include but not be limited to:
>
> (1) An analysis of present and anticipated uses, demand for, and supply of the renewable resources of forest, range, and other associated lands with consideration of the international resource situation, and an emphasis of pertinent supply and demand and price relationship trends;
>
> (2) An inventory, based on information developed by the Forest Service and other Federal Agencies, of present and potential renewable resources, and an evaluation of opportunities for improving their yield of tangible and intangible goods and services ...,
>
> (3) A discussion of important policy considerations, laws, regulations, and other factors expected to influence and affect significantly the use, ownership, and management of forest, range, and other associated lands."

In accordance with the provisions of the legislation, this Assessment presents an analysis of the present situation and the outlook for outdoor recreation and wilderness, wildlife and fish, forest-range grazing, timber, and water. It includes information on:

- Trends in use and prices of major products of forest and range lands and inland waters, such as timber, forage, water, outdoor recreation and wilderness, wildlife, and fish.
- International trade in timber and range products and the timber resources of important trading countries.
- Long-run projections of demand for major products.
- The extent, location, ownership, condition, and productivity of the Nation's 1.7 billion acres of forest and range lands and associated inland waters.
- The uses of the forest and range lands and inland waters including use for designated purposes such as parks, refuges, wildernesses, and mines.
- Recent changes in the area, ownership, use, and productivity of forest and range lands and inland waters.
- The capacity of forest and range lands and the associated inland waters to meet projected demands for renewable resource products.
- Economic, social, and environmental implications of the relationship between longrun projections of demands and supplies.
- Opportunities for increasing and extending supplies of major products beyond the levels attainable with present programs, with analysis of the related economic, social, and environmental impacts.
- Potential resource interactions resulting from changes in the management of forest and range lands.
- The discussion of important policy considera-

[1] Hough, Franklin B., Report upon forestry. U.S. Gov. Print. Office, Washington; Vol. I, 650 p., 1978; vol. II, 618 p. 1880; Vol. III, 318 p., 1882.

[2] Section 9 of this Act authorized and directed the Secretary of Agriculture to cooperate with States, private owners, and other agencies "... in making and keeping current a comprehensive survey of the present and prospective requirements from timber and other forest products in the United States, and potential productivity of forested land therein and of such other facts as may be necessary in the determination of ways and means to balance the timber budget of the United States."

[3] Congressional interest in an assessment of the range situation was first expressed in 1934. This resulted in the preparation of the first range assessment — U.S. Department of Agriculture, Forest Service. The western range. A report to the Senate. S. Doc. No. 199, 74th Cong., 2nd Sess. 620 p. 1936.

[4] Section 3(a)(1) and (2), Section 3(c) and Section 5(5)(E).

tions, laws, and regulations as described under (3) above is interwoven throughout the report.

This assessment also includes a discussion[5] of the additional fiber potential in the Nation's forests; opportunities for increased utilization and recycling of forest, processing, and urban wood and fiber residues; primary wood manufacturing and processing facilities; the impact of the export and import of logs upon domestic timber supplies and prices; and the role of urban areas in meeting the demands for renewable resource products.

A number of needs are served by the descriptive material and data on the forest and range lands and inland water base; the ownership, use, and productivity of these lands and waters; and on uses, prices, and international trade in products. Such material and data provide a factual basis for judging the results of forest and range land policies and programs. In addition, it provides a basis for analyzing trends in markets and prices of many products, for appraising the need for and the economic feasibility of expanding manufacturing, ranching, and recreational facilities, and for identifying the States and regions where forest and range land resources can support such expansion. It also provides the factual foundation required for projecting future trends in demands and supplies for renewable resource products.

The material on future demands and the capacity to meet these demands is a very basic part of the Assessment. The demand projections show the volume of forest and range land and water products that people would like to consume under the given assumptions on future changes in population, economic activity, income, energy costs, technology, institutions, relative prices, and other determinants. The supply material describes the capacity of forest and range lands and the associated waters to meet these demands if recent trends in investments, management, utilization, research, and facilities continue through the projection period.

Comparisons of the demand-supply projections thus provide a means of identifying future imbalances between the volume of products that would be consumed under the given assumptions on demand determinants and the volume that would be available for use if recent trends in investments continue. In addition, these projections provide a basis for estimating prospective increases in relative prices of products, such as timber and forage, necessary to bring about an equilibrium between the projected demands and supplies. They also provide a measure of the unsatisfied demand for products where the price system does not act to bring about an equilibrium.

The projections of timber demands and supplies and the equilibrium prices provide guidance for many decisions on long-range commitments, such as the construction of recreation or manufacturing facilities or investment in management practices such as reforestation or habitat improvement whose effects can be realized only over an extended period. They also provide a basis for analyzing the economic, social, environmental, and resource implications which would result from a continuation of recent trends in investments in management, research, assistance, and construction programs. This analysis is the key to determining whether to continue existing policies and programs or to change them in ways perceived to be more desirable from the standpoint of the economy and the society.

This is the second in the series of required Assessments under the Renewable Resources Planning Act as amended. The first Assessment[6] was submitted to Congress in March 1976. Although that Assessment, and the associated Forest Service Program, were used in the Executive Branch and Congress in formulating and funding Forest Service programs, it is too early to appraise the more general effects on renewable resource policies and programs. The impacts of the earlier assessments of the forest situation, however, are clear.[7] These past assessments have played an important role in the development and guidance of public and private forest policies and programs. They have defined problems, aroused public interest, and provided a factual and analytical foundation for policies and programs that had profound impacts upon the management of the Nation's forest resource. Uses of these kinds are evident in the records of hearings held before Federal and State legislative committees on forestry legislation and the budget statements prepared by forestry agencies requesting funds for forest programs. Available information suggests that the recent assessments have been used in much the same way in the private sector — to identify prospective supply problems and as a factual and analytical base for the establishment and funding of forestry programs.

In preparing this Assessment, the demand and supply analysis required by the basic legislation has necessarily been confined to the more tangible products of forest and range lands and inland waters. It

[5] This discussion is included as a response to the direction in Section 3(c) and Section 5(5)(E) of the Renewable Resources Planning Act as amended by the National Forest Management Act.

[6] Forest Service, U.S. Department of Agriculture. The Nation's renewable resources — an assessment, 1975. For. Resource Rep. 21, U.S. Gov. Print. Off., Washington, D.C. 243 p. 1977.

[7] The most recent of these assessments are cited in the timber chapter of this document.

is recognized, however, that these lands and waters provide intangible goods and services that are important to many and contribute to the quality of life for all people.

The demand and supply analysis is also of necessity concerned with individual products. However, an effort has been made to recognize the increasing emphasis on multiple-use management, protection of the forest and range environment, and the multiple resource interactions which will result from increased output of products. Specific allowances were made for the continuing transfer of forest and range lands to other uses in estimating demand and supply of such products as timber and forage where area changes have substantive effects.

The analysis in this study covers the next five decades. For the longer run, with growing population pressure on the environment and accelerated use of nonrenewable stocks of ores and fuels, forest and range lands and the renewable resources products they provide will become increasingly important to the economy and the society.

Thus, in appraising the needs for programs and the urgency for action, consideration must be given to the situation beyond the period covered in this report. With proper management, the output of renewable forest and range products, including intangibles, can in time be greatly increased and higher levels of output maintained for future generations.

Highlights

Most decisions on the management and use of the Nation's forest and range lands and associated waters have long-term impacts on the output of forest, range, and water products; in a broader sense of the society, the economy, and the natural environment. The purpose of this Assessment is to provide a factual and analytical basis for making these decisions. Thus, and as directed by Congress, this Assessment is primarily concerned with prospective trends in demands and supplies of forest, range, and water products; the economic, social, and environmental implications of these trends, the forest and range land and water base; and the opportunities to manage and use this resource base in ways which will enhance the quality of life for present and future generations.

An Assessment of this kind must be based on a series of assumptions on the basic determinants of demand and supply, such as growth in population, economic activity, and income; technological and institutional changes; energy costs; capital availability; and investments in forest, range, and water management, utilization, assistance, and research programs.

In making assumptions about these basic determinants, it is recognized the longrun course of events may be quite different from what is assumed here.[1] However, trends in these determinants are the result of massive economic, social, and political forces which are not easily or quickly changed. Barring major catastrophes, such as a world war, such trends are likely to continue over a considerable time. Thus, it is reasonably certain that the given basic assumptions provide a realistic basis for preparing an Assessment for use in developing and guiding renewable resource policies and programs in the 1980's. Near the end of that decade, and as required by the Renewable Resources Planning Act, another Assessment will be prepared. At that time, the basic assumptions will be reevaluated and new expectations incorporated in the Assessment which will guide Forest Service policies and programs in the 1990's.

[1] The course of events in the short run can also vary from that assumed. However, the variation which could be reasonably expected is not likely to have major impacts on most projections. For example, if the rate of increase in the gross national product in the 1977-90 years continued during the last 5 years at the average rate of 2.8 percent instead of the assumed rate of 3.7 percent, the demand for outdoor recreation in 1990 would only be reduced 1 percent below the medium projected level. There would be bigger reductions in the demand for most timber products, about 5 percent for lumber and plywood. But the reductions would not be large enough to significantly change the basic timber demand-supply outlook or the projected increases in timber prices.

(1) Substantial growth is anticipated in population, economic activity, and income

In the five decades since the late 1920's, the population of the United States has increased by about 97 million people, to the 1979 level of 220 million. The most recent projections of the Bureau of the Census indicated that population is likely to continue to grow fairly rapidly during the next five decades. The Census Series II projection — the medium projection of this report — shows population rising by another 80 million to 300 million. In line with recent trends, however, the annual rate of growth will decline from about 1 percent in the late 1960's and early 1970's to 0.3 percent in the decade 2020-2029.

Between 1929 and 1978, the gross national product, measured in constant 1972 dollars, increased more than four times to $1,386 billion. Projections prepared by the Bureau of Economic Analysis indicate a gross national product of $2,690 billion (1972 dollars) in 2000 — nearly twice that of 1978. By 2030, it would amount to $5,160 billion — some 3.7 times that of 1978. The associated projection of per capita gross national product in 2030 would rise to $17,180 — nearly triple the 1978 average.

Disposable personal income, i.e., the income available for spending by the Nation's population, is projected to grow from about $960 billion in 1978 to $3,610 billion (1972 dollars) in 2030.

Per capita disposable income is projected to rise to $12,020 in 2030, some 2.7 times the 1978 average. This growth would mean that the Nation is faced not only with the task of meeting the resource demands of an additional 80 million people, but the demands of 300 million people with much greater purchasing power than today's population.

(2) Consumption of forest and range land products has been rising rapidly

In response to past increases in populations, economic activity, and income, the consumption or use of nearly all products of forest and range lands, and associated inland waters, has risen rapidly. For example, the number of camping households has roughly quadrupled since the early 1960's and now totals around 15 million. Timber consumption has increased from a level of around 11.5 billion cubic feet to 13.7 billion cubic feet in 1977.

(3) Projections show demands for forest and range products rising faster than supplies

Projections based on expected increases in population, economic activity, and income show that the demands on forest and range lands and the associated waters for outdoor recreation, wildlife, forage, timber, and water are likely to continue to grow rapidly in the decades ahead. However, as indicated in figure 1, there are differences in the amount of the increase.

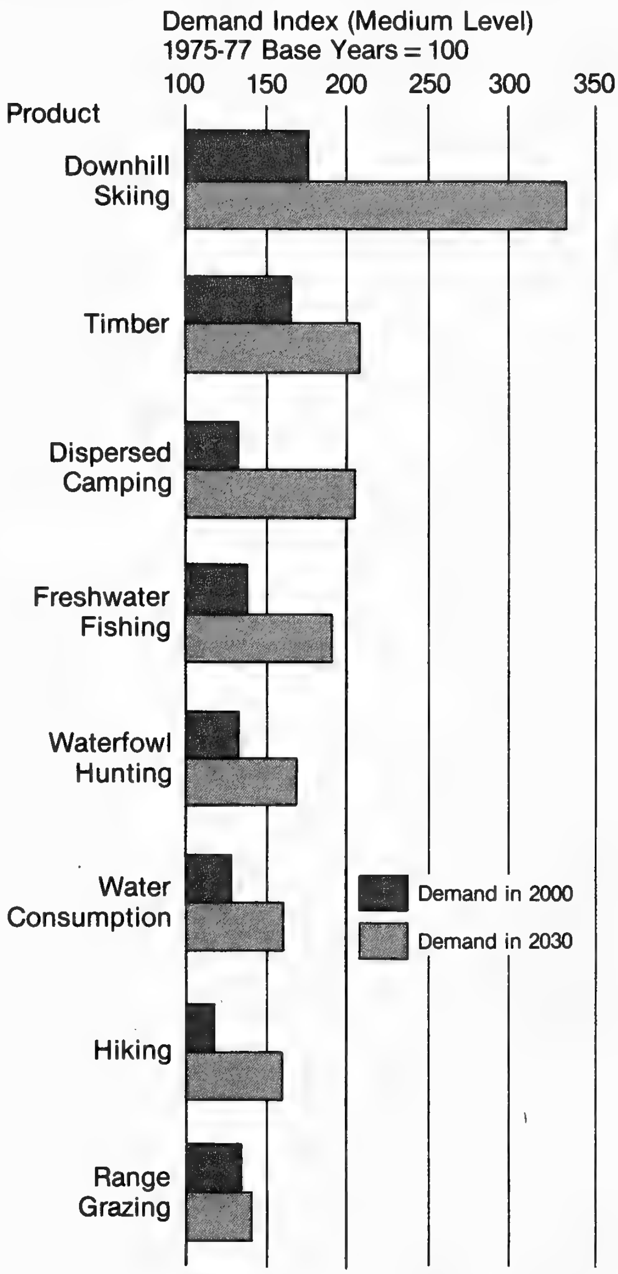
Despite the differences, the projected growth in demand is substantial for all products. On the other hand, and as schematically illustrated in figure 2, the capacity to meet these demands, assuming a continuation of recent trends in investments in forest and range land and water programs and facilities, shows slower increases. Thus, the Nation is faced with a growing imbalance between supply and the quantity of forest, range, and water products that people would like to consume.

This outlook has some important and adverse economic, social, and environmental implications. For example, the projected imbalance between demand and supply for timber means that the Nation is faced with the prospect of rapid and continuing increases in the prices of stumpage (standing timber) and timber products, relative to the general price level and to prices of most competing materials. This, in turn, means that the economy must depend to an increasing degree on imports of timber products and substitute materials. It also means increased cost to consumers of products such as houses and furniture made wholly or in part from wood; rising environmental costs resulting from the mining, industrial processing, and power generation associated with the increased use of substitute materials, and an acceleration in the rate of use of nonrenewable resources.

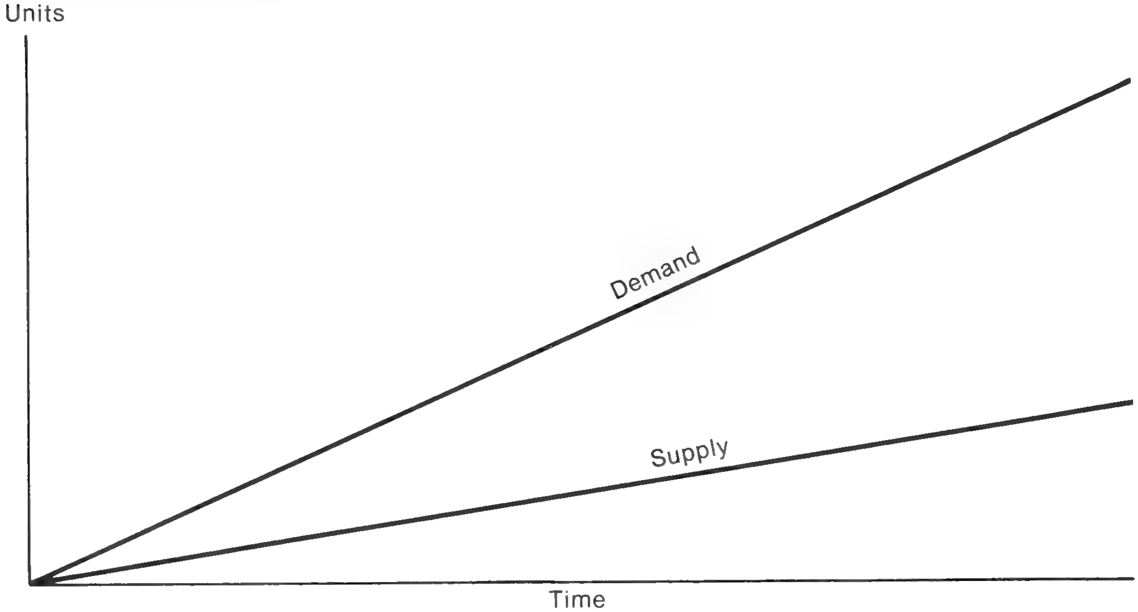
The outlook for forage and water is similar in many respects — higher costs to consumers with the associated impacts on the economy, the environment, and the society.

For users of wildlife, fish, and outdoor recreation resources, it will mean intensifying competition for the available resources. This may well lead to shrinking populations of wildlife and fish and a more restricted distribution; fewer and less satisfying outdoor recreation opportunities for such activities as camping, hunting, birdwatching, and wilderness camping; and overall, a gradual deterioration in the quality of life which the Nation has come to appreciate and expect.

Projected Demand Increases for Selected Products



Schematic Illustration of Projected Demands and Supplies for Renewable Resources Products



(4) The Nation has a huge forest and range land and water base

The widespread and the adverse effects associated with this outlook are not inevitable. There is a huge forest and range land and water base which can be used to meet demands for nearly all products. In 1977, 1.7 billion acres, some 71 percent of the Nation's area, was classified as forest and range land and water. A little over half, or some 820 million acres, was classified as rangeland (fig. 3). This land includes natural grasslands, savannas, shrublands, most deserts, tundra, coastal marshes, and wet meadows. Another 737 million acres was classified as forest land, i.e., land that is at least 10 percent stocked with forest trees, or formerly had such cover, and not currently developed for other uses. Of this area, about 482 million acres is commercial timberland, i.e., land capable of producing in excess of 20 cubic feet of industrial wood per acre per year in natural stands and not withdrawn for other uses. The remaining area — some 107 million acres — was classified as water and consisted of lakes, reservoirs, ponds, streams, and estuaries.

Nearly three-tenths of the rangeland, some 231 million acres, is in Alaska. Most of the remainder is in the States stretching westward from the Great Plains to the Pacific Coast. Relatively little is found in the island territories and possessions.

Forest and commercial timberlands are more widely distributed and, with the exception of the Great Plains and some of the Southwest, compose a significant part of the area of each State. However, nearly three-quarters of the commercial timberland area is in the humid eastern half of the country where it is about equally divided between the North and South. The one-quarter of the commercial timberland in the West is located in the Rocky Mountain States of Montana, Idaho, and Colorado. The other forest land — 254 million acres — is concentrated in Alaska and the Rocky Mountain States.

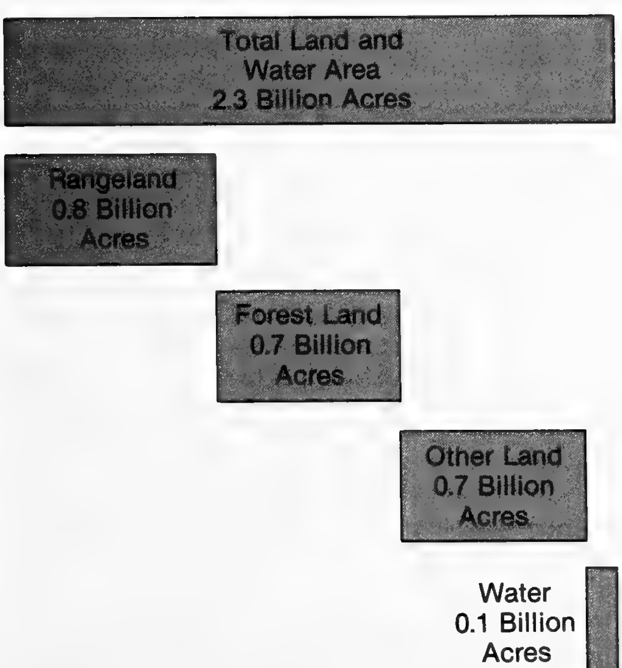
The water area in the United States, including estuaries associated with the contiguous States, is 107 million acres, about 5 percent of the Nation's total area. Nearly half of the water area, some 50.9 million acres, is in lakes and ponds at least 40 acres in size or streams 1/8 of a mile or more in width. Slightly more than half of this, 27.3 million acres, is in the humid eastern half of the country. Another 12.8 million acres, about a quarter of the total large water area, is in Alaska. Most of the remainder, some 10.8 million acres, is in the West. A substantial part of this area is manmade reservoirs and impoundments constructed

to store water for irrigation, electric power generation, and flood control.

The area in small streams less than 1/8 mile in width and lakes and ponds between 2 and 40 acres in size amounts to 8.1 million acres, or about 8 percent of the total water area. The geographic distribution of these small water areas is similar to that for the large water areas, and generally for the same reasons, primarily rainfall and land form. A significant part of these small water areas in nearly all States is man-made, largely the product of Federal and State programs concerned with watershed protection and flood prevention.

The remaining water area, 47.6 million acres, includes the Great Lakes; bays such as the Chesapeake, Delaware, and San Francisco; sound such as Long Island and Puget; harbors such as New York; Straits of Juan de Fuca and Georgia and other coastal waters along the Atlantic, Gulf, and Pacific Coasts except those in Alaska and Hawaii. As a result of the inclusion of the Great Lakes, three-quarters of this other water area is in the North Central region. Most of the rest is in the Atlantic and Gulf Coast States and in Washington.

Land and Water Areas of the United States



(5) The bulk of the forest and range land is privately owned

The great bulk of the Nation's forest and range land is in private ownerships. In 1977, the area in these ownerships, plus relatively small areas in State, county and municipal ownerships, amounted to 832 million acres — about 53 percent of the total forest and range land area.

Some 381 million acres or 46 percent of the rangeland area in 1977 was in non-Federal ownership, nearly all private (fig. 4). These lands are concentrated in the Rocky Mountain and Great Plains States and in Oregon and California. There are large acreages of rangelands in Federal ownership in such Rocky Mountain States as Nevada, Utah, Wyoming, and Colorado. In addition, in Alaska nearly all of the rangeland — some 231 million acres — was in Federal ownership.

Approximately 451 million acres, or 61 percent of the Nation's forest land, was in non-Federal ownerships in 1977 (fig. 5). Much of this area is in productive sites and close to markets for timber products. These ownerships, consequently, have long been of major importance as a source of timber supplies for the wood-using industries. Forty-five percent of these forests are in the South, with most of the remainder in the North.

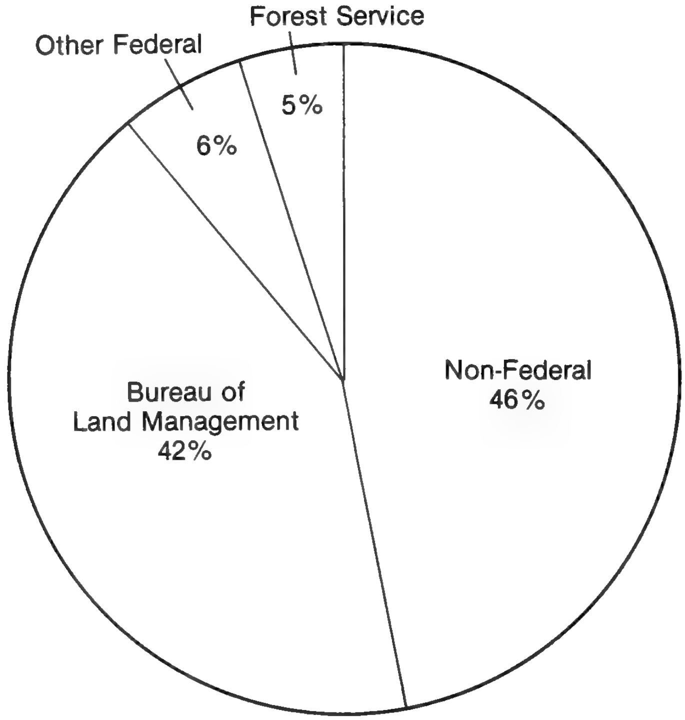
The 286 million acres of forest land in public ownership, largely Federal, is concentrated in the Rocky Mountains and Pacific Coast sections. Most lands are of relatively low site quality and located at higher elevations. Because a substantial part of these forests has never been harvested, they contain a large part of the Nation's timber inventory — somewhat more than half of the softwood sawtimber.

(6) Production on forest and range lands is below potential

The output of nearly all renewable resource products from forest and range lands varies widely as a result of differences in climate, soils, elevation, and latitude. In general, however, it is much below what can be attained. In 1976, for example, range grazing in the contiguous United States amounted to 217 million animal unit months, which is only a little over a third of the biological potential.

The situation on commercial timberland is similar to that on rangeland. Average net annual timber growth per acre in 1976 was 49 cubic feet. This is three-fifths of what can be attained in fully stocked natural stands and far below what can be achieved with intensive management practices such as spacing

Ownership of Rangeland



control and the use of genetically improved stock and fertilizers. The potential for increasing timber growth exists in all regions and on all ownerships. The largest potential, however, is on the farmer and miscellaneous private ownerships which collectively contain 58 percent of the Nation's commercial timberlands. Most of these lands are advantageously located with respect to markets and are largely composed of the more fertile sites used for timber production.

In addition to increasing timber growth, there is a large potential for extending timber supplies through improvements in utilization. Logging and primary manufacturing plant residues in 1976 totaled about 2 billion cubic feet. About 67 billion cubic feet of wood was represented in rough and rotten and salvable trees, and dead trees. Large additional volumes were in tops, limbs, and stumps and urban wood wastes. Although part of the available residue is in remote locations or occurs in such small volumes as to be unusable, much of the material is potentially suitable for pulp or fuel.

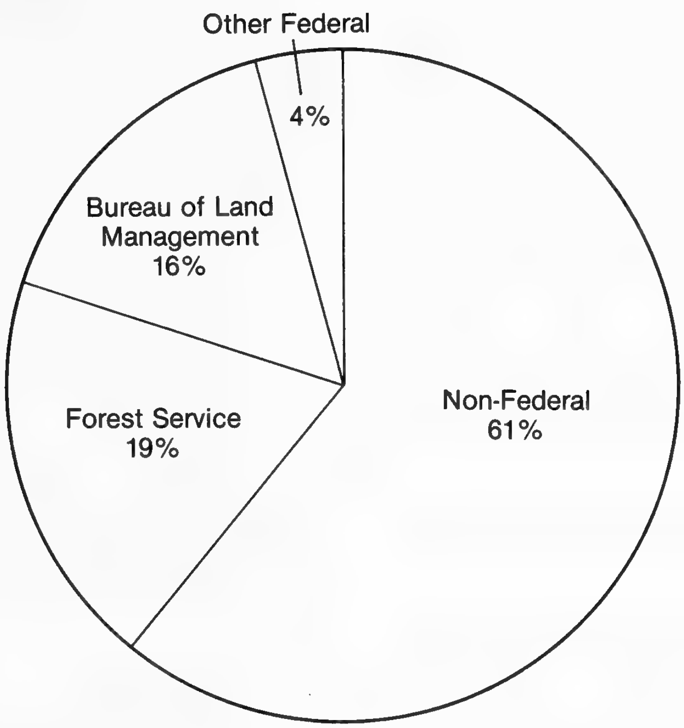
Increased efficiency in processing, manufacturing, and construction can also significantly extend the available wood supplies.

There is no quantitative way of comparing present production of outdoor recreation with the potential. However, the 1.7 billion acres of forest and range lands and the associated waters have the physical capacity to supply sites for picnicking, camping, hiking, skiing, birdwatching, canoeing, swimming, and most other types of outdoor recreation far in excess of foreseeable increases in demand.

Forest and range lands and waters also have the potential to support a greater diversity of wildlife species and increased numbers of most wildlife and fish species. Included are species of high recreational and commercial importance and some that are classified as endangered or threatened by the Federal and State governments. Commercial stocks of fish and wildlife can support more jobs and provide protein for human consumption through improvements in habitats, appropriate harvest regulations, and other activities.

Research has shown that water yields from forest and range lands can be augmented by intensive management. Watershed management can significantly improve water quality and reduce soil erosion including the associated sedimentation of streams.

Ownership of Forest Land



(7) Opportunities exist to greatly increase production of renewable resource products of forest and range lands — enough to meet projected demands for nearly all products

In summation, the Nation's 1.7 billion acres of forest and range land and waters have the physical potential to produce much larger quantities of renewable resource products — enough to meet the projected demands for nearly all products. The potential for increased output and use exists in all regions of the country, on all ownerships and for all products.

Achieving this potential will require more intensive management of much of the land and water base, the integration of all renewable resources in management plans, construction of new facilities, improvements in the efficiency of utilization, and the preservation of some renewable resources. More specifically, and by element, it will involve:

Outdoor Recreation

- Providing adequate maintenance of existing facilities and improved pollution abatement.
- Constructing additional facilities such as trails, campgrounds, picnic areas, and boat ramps.
- Improving access to forest and range land suitable for outdoor recreation, especially near urban areas.
- Providing improved opportunities to inform and educate people about outdoor recreation opportunities.
- Coordinating and integrating outdoor recreation, including scenic values, with other uses in resource and land planning.
- Coordinating the planning and implementation improve cover, stock desirable species, and more fully integrate wildlife and fish into the management of the forest, rangeland, and water base.
- Defining, protecting, and augmenting habitats of endangered and threatened species and protecting critical habitat of other species threatened by changes in the management or use of the land and water base. Transplanting or artificially rearing individuals in some circumstances.
- Expanding waterfowl wetlands nesting habitats through fee purchase of key tracts and wetlands

easements in the United States and Canada, and preserving and enhancing migration and wintering habitats.

- Fully integrating the planning, development, and use of fish with other water resources. Avoiding damage to fish by terrestrial resource use. Ensuring free passage of anadromous species.
- Providing access by constructing trails, boat landings, and other facilities where the existing wildlife and fish resources are underutilized, and spreading use through time and to developed areas where the resources can support additional use.
- Limiting the harvesting of wildlife and fish to long-run sustainable levels.
- Improving the coordination of wildlife-and fish-centered activities of all levels of government and of the private sector.

Range Grazing

- Shifting grazing from ecosystems with low response to those with higher efficiency of forage production.
- Intensifying management on all ranges in all ownerships to improve range conditions, promote production of palatable and nutritious forage, obtain uniform forage utilization, and meet needs of other uses besides grazing.
- Improving the amount and quality of forage produced by seeding, seeding improved forage species on selected sites, controlling less productive or less palatable plants on selected areas, controlling poisonous and noxious plants, and employing land treatments to increase production on selected area.
- Constructing needed livestock control and handling facilities.
- Reducing loss of range forage by controlling wildfire and range insects and diseases.
- Reducing livestock loss to diseases, parasites, and predators.

Timber

- Increasing the net annual growth and improving tree quality by such measures as controlling species composition, stand density, and age classes; prompt restocking of harvested stands; reforestation of nonstocked areas; use of genetically improved planting stock; control of harvesting methods; and maintaining site quality.
- Extending wood supplies through increased use of wood residues; more efficient harvesting, manufacturing, and construction practices; increased use of preservative-treated products and improved maintenance of existing structures.
- Reducing timber losses through integrated management techniques which prevent or minimize losses caused by suppression, insects, diseases, and other destructive agents.

Water

- Intensifying watershed protection and management of forest and range lands to enhance the natural recharge of groundwater and improve the timing of flows by storage or vegetation modification, improve water quality, prevent erosion of productive land, and reduce the sedimentation of streams.
- Increasing the efficiency of irrigation systems by reducing losses from transmission systems and phreatophytes and improving application methods.
- Improving the efficiency of central supply systems by elimination of leaks in transmission systems, use of water meters with charges according to use, and implementation of water-saving technology such as more efficient plumbing fixtures and appliances.
- Pricing to encourage more efficient use of water.

General Opportunities

- Various studies have shown that most private owners, who collectively control most of the Nation's forest and range lands, have diverse objectives, widely different characteristics and attitudes, a limited knowledge of existing management opportunities, and varying willingness and capacity to make investments which will increase and extend supplies of forest and range products.
- Substantial increases in the supplies of most forest and range products from these ownerships can only be achieved by such measures as cost-sharing programs to help finance management practices, and technical assistance and educational programs to show landowners how to develop and manage forest and range resources.
- Much can be done to increase and extend supplies of forest and range products by better use of existing technology and by further research to develop new technology. Investments in management practices and facilities could be made more efficient by expanding research. More information is needed about physical responses in terms of changes in wildlife populations and in forage and timber growth to various kinds of management practices. More data are also needed on the cost of manage-

ment practices, the prices and uses of forest and range products, and the physical aspects of the forest and range resource. Need for research is becoming increasingly urgent on ways of using forest and range land, and water, which will minimize impacts on the environment.

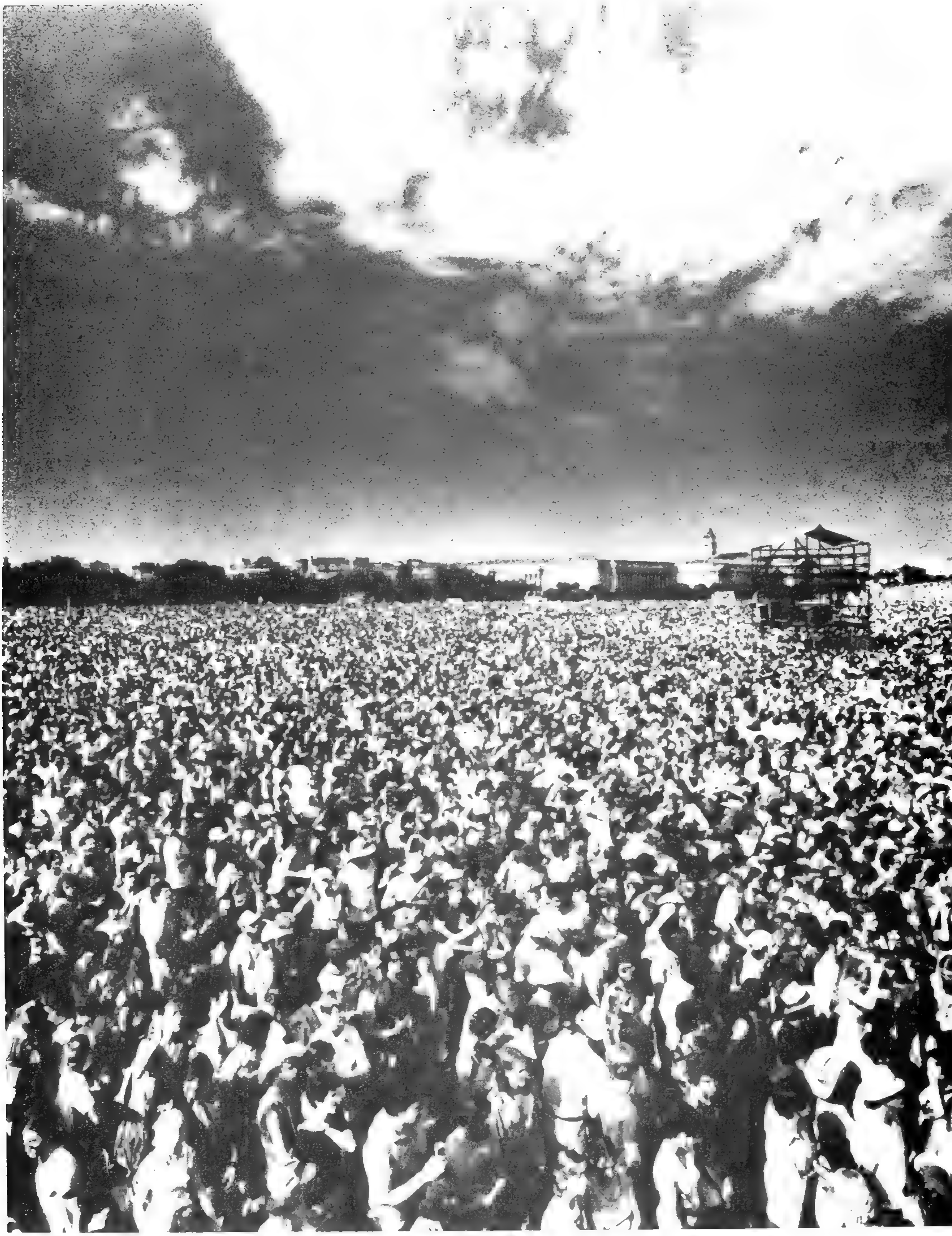
- Inevitably in expanding programs to increase supplies of forest, range and water products, the point will be reached where increasing the output of one product will constrain or reduce the output of another. Research is perhaps the best hope of developing ways of integrating and balancing multiple uses of renewable resources and reducing the conflicts which are likely to result from rapidly expanding demands.
- Finally, there is the need to further explore the economic, social, and environmental implications of a future in which the demands for nearly all forest and range land products are increasing more rapidly than supplies. This is a basic need — it is the societal basis for changing policies and programs. The results of this research are likely to have profound impacts on the future management and use of the Nation's forest, range, and water resources.

(8) Moving forward to meet projected demands for forest and range products requires substantial investments, but these investments promise to be profitable

Increasing and extending supplies of renewable resource products is technically feasible and can be done while maintaining the forest and range environment. However, substantive progress in meeting prospective increases in the demand for forest, range, and water products will require large public and private investments in a variety of management, research, and assistance programs. Large expenditures will also be required to provide the necessary physical facilities and the plant and equipment needed to harvest, process, and use the additional supplies of products.

It has not been feasible in this Assessment to evaluate in aggregative ways the costs and benefits associated with moving forward to meet demands for renewable resource products. However, the partial analyses that have been made indicate that when the economic, social, and environmental benefits are considered, the investments are likely to be profitable from the standpoint of the society and the economy.

Contents



Chapter 1. — Basic Assumptions

This chapter presents the general basic assumptions used in making demand and supply projections for outdoor recreation and wilderness, wildlife and fish, forest-range grazing, timber, and water which are presented in following chapters. In partial recognition of the uncertainty about future changes, three alternative assumptions are presented for population, economic activity, and income. The alternatives cover the range over which growth in these major determinants, and the associated projections of demand for renewable resource products, could reasonably be expected to vary. They also illustrate the sensitivity of the demand projections to changes in these basic determinants.

In making the general assumptions used here, it is recognized that completely accurate predictions about longrun population and economic growth, or any of the other determinants of demand for or supply of renewable resource products, are beyond attainment. The intent is to make assumptions, based on historical trends, current knowledge about developments which affect these trends, and present expectations about future changes which can be generally accepted as reasonable at this time.

Past trends in the major determinants used here result from massive social, political, technological, and institutional forces that are not easily or quickly changed. Barring major catastrophes, such as a world war or depression, recent trends are likely to persist over a considerable time. Thus, basic assumptions, derived as described, provide a realistic basis for preparing an assessment for the development and guidance of renewable resource policies and programs in 1980's. Near the end of that decade, and as required by the Renewable Resources Planning Act, the basic assumptions will be reevaluated; new expectations will be incorporated in the assessment which must be submitted to Congress in 1990.

Population

Changes in population have an important effect on the demand for outdoor recreation, wildlife and fish, timber, forage, water, and the other forest, range, and inland water products included in this study. They also influence the size of the labor force, a major determinant of the level of economic activity and related materials use.

In the five decades between the late 1920's and the late 1970's, the population of the United States increased by about 98 million people, rising at an average annual rate of 1.2 percent (table 1.1, fig. 1.1). The most recent projections of the Bureau of the Census[1] indicate that population is likely to continue to grow fairly rapidly through the projection period. The Census Series II projection — the medium projection of this study — shows population rising by another 81 milion by 2030. In line with recent trends, however, the annual rate of growth declines from about 1 percent in the late 1960's and early 1970's to 0.3 percent in the decade 2020-2029.

The alternative projections (Series I and III) prepared by the Bureau of Census show substantial increases in population. However, under the low projections (Series III) nearly all of this occurs prior to 2010-19 decade and begins to decline in the first half of the following decade.

The decline in the rate of population growth reflects Bureau of the Census assumptions about fertility rates.[2] Fertility rates fluctuated widely in recent decades, but since the late 1950's have fallen sharply. The medium projection is based on an assumed fertility rate of 2.1 — a level close to current birth expectations of young American wives.[3] The current fertility rate is below this figure and approximates a level which would end population growth in the first part of the twenty-first century.

Legal immigration accounts for a significant part of population growth, and the estimates shown in table 1.1 includes a net addition of 400,000 immigrants each year. Legal immigration has declined recently and some further reduction could result from growing national concern about unemployment and population pressure on resources and the environment. No allowance has been made for illegal immigration.

The geographic distribution of the population has a strong influence on State and regional demands for renewable resources, particularly those that must be produced and consumed at the same place. State projections prepared by the Bureau of Economic Analysis,[4] are used as the basis for regional projections in this work. They show significant differences

[1] U.S. Department of Commerce, Bureau of the Census. Population estimates and projections. "Projections of the population of the United States: 1977 to 2050." Cur. Pop. Rep. Ser. P-25, No. 704, U.S. Government Printing Office, Washington, D.C. 87 p. 1977.

[2] Fertility rates indicate the number of births per 1,000 women during their childbearing years. For a more detailed technical definition, see U.S. Department of Health, Education, and Welfare, Public Health Service. Natality statistics analysis United States, 1965-67. National Center for Health Statistics, Ser. 21, No. 19, U.S. Government Printing Office, Washington, D.C. 39 p. 1970.

[3] U.S. Department of Commerce, Bureau of the Census. Population characteristics. "Fertility of American women: June 1976." Cur. Pop. Rep. Ser. P-20, No. 308, U.S. Government Printing Office, Washington, D.C. 75 p. 1977.

[4] U.S. Department of Commerce, Bureau of Economic Analysis. Population, personal income, and earnings by State projections to 2030. 25 p. 1977.

Table 1.1 — *Population, gross national product, and disposable personal income in the United States, selected years 1920-78, with projections to 2030*

Year	Population		Gross national product[1]		Per capita gross national product		Disposable personal income[1]		Per capita disposable personal income	
	Millions	*Annual rate of change*	*Billions of 1972 dollars*	*Annual rate of change*	*1972 dollars*	*Annual rate of change*	*Billions of 1972 dollars*	*Annual rate of change*	*1972 dollars*	*Annual rate of change*
1929	121.8	---	314.6	---	2,583	---	229.8	---	1,886	---
1933	125.7	0.8	222.1	-8.3	1,767	-9.1	169.7	-7.3	1,350	-8.0
1940	132.6	.8	343.3	6.4	2,589	5.6	244.3	5.3	1,849	4.6
1945	140.5	1.2	560.0	10.3	3,986	9.0	338.6	6.7	2,420	5.5
1950	152.3	1.6	533.5	-1.0	3,503	-2.6	361.9	1.3	2,386	- .3
1955	165.9	1.7	654.8	4.2	3,947	2.4	425.9	3.3	2,577	2.6
1960	180.7	1.7	736.8	2.4	4,077	.7	487.3	2.7	2,697	.9
1965	194.3	1.5	925.9	4.7	4,765	3.2	612.4	4.7	3,152	3.2
1970	204.9	1.1	1,075.3	3.0	5,248	1.9	741.6	3.9	3,619	2.8
1971	207.1	1.1	1,107.5	3.0	5,348	1.9	769.0	3.7	3,714	2.6
1972	208.8	.8	1,171.1	5.7	5,609	4.9	801.3	4.2	3,837	3.3
1973	210.4	.8	1,235.0	5.5	5,870	4.7	854.7	6.7	4,062	5.9
1974	211.9	.7	1,217.8	-1.4	5,747	-2.1	842.0	-1.5	3,973	-2.2
1975	213.6	.8	1,202.3	-1.3	5,629	-2.1	859.7	2.1	4,025	1.3
1976	215.2	.7	1,273.0	5.9	5,915	5.1	891.8	3.7	4,144	3.0
1977	216.9	.8	1,340.5	5.3	6,180	4.5	929.5	4.2	4,285	3.4
1978	218.5	.7	1,399.2	4.4	6,404	3.6	972.5	4.6	4,449	3.8
Low projections										
1990	236.3	.7	1,940	3.2	8,210	2.5	1,360	3.2	5,760	2.5
2000	245.9	.4	2,410	2.2	9,800	1.8	1,690	2.2	6,870	1.8
2010	250.9	.2	2,940	2.0	11,720	1.8	2,060	2.0	8,210	1.8
2020	253.0	.1	3,410	1.5	13,480	1.4	2,390	1.5	9,450	1.4
2030	249.3	-.1	4,000	1.6	16,040	1.8	2,800	1.6	11,230	1.7
Medium projections										
1990	243.5	.9	2,070	3.7	8,500	2.8	1,450	3.7	5,950	2.8
2000	260.4	.7	2,690	2.7	10,330	2.0	1,880	2.6	7,220	2.0
2010	275.3	.6	3,440	2.5	12,500	1.9	2,410	2.5	8,750	1.9
2020	290.1	.5	4,190	2.0	14,440	1.5	2,930	2.0	10,100	1.4
2030	300.3	.3	5,160	2.1	17,180	1.8	3,610	2.1	12,020	1.8
High projections										
1990	254.7	1.2	2,200	4.2	8,640	2.9	1,540	4.2	6,050	2.9
2000	282.8	1.1	3,010	3.2	10,640	2.1	2,110	3.2	7,460	2.1
2010	315.2	1.1	4,050	3.0	12,850	1.9	2,840	3.0	9,010	1.9
2020	354.1	1.2	5,180	2.5	14,630	1.3	3,630	2.5	10,250	1.3
2030	392.8	1.0	6,700	2.6	17,060	1.5	4,690	2.6	11,940	1.5

[1]Preliminary.

Note: Annual rates of increase were calculated for the various periods indicated, except for the 1990 projections which were derived from the 1977 trend level ($1,290 billion) for gross national product.

Sources:

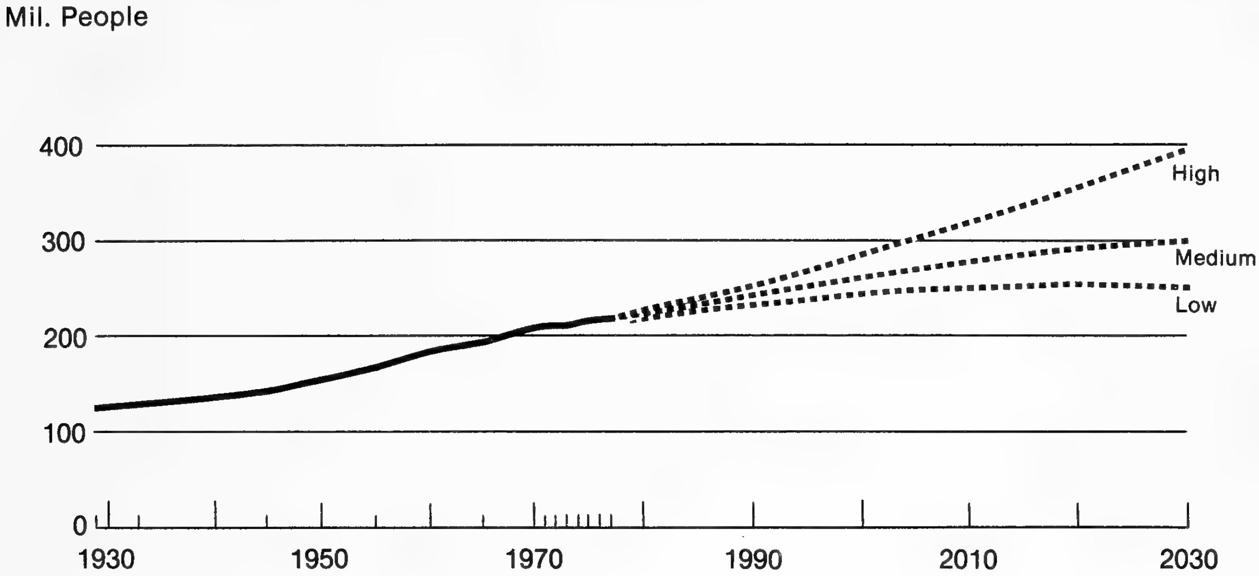
Population: U.S. Department of Commerce, Bureau of the Census. *Population estimates and projections.* Curr. Pop. Reps. Ser. P-25. 1929-69 — "Estimates of the population of the United States and components of change: 1940 to 1978." No. 802, 14 p. 1979. 1970-78 — "Estimates of the population of the United States to August 1, 1979." No. 864, 2 p. 1979. Projections — "Estimates of the population of the United States: 1977 to 2050." No. 704, 87 p. 1977.

Gross national product: Council of Economic Advisers. 1929-78 — *Economic report of the President.* 329 p. January 1980. Projections, Medium — U.S. Department of Commerce, Bureau of Economic Analysis. Unpublished data. Projections, Low and High — U.S. Department of Agriculture, Forest Service.

Disposable personal income: Council of Economic Advisers. 1929-78 — *Economic report of the President.* 329 p. January 1980. Projections — U.S. Department of Agriculture, Forest Service.

Figure 1.1

Population 1929-77, with Projections to 2030



in population trends among the States and regions. In general, the most rapid growth will be in the South and on the Pacific Coast. Rapid growth is also likely in some areas in the Rocky Mountains. The major population concentrations, however, will be much as they are today in the North Central region and in the regions along the Atlantic and Pacific Coasts.

The age distribution of the population is another significant factor in estimating demands for many renewable resource products, especially for outdoor recreation. The Bureau of the Census projections of age classes associated with the population projections shown in table 1.1 have been used in this study. These projections indicate a substantial increase during most of the projection period in the number and proportion of people in the middle age classes — the classes that have the highest income levels and the largest demands for goods and services.

Population is also important as a determinant of the labor force, which in turn is a major determinant of the gross national product. The labor force associated with the medium population projection is expected to grow somewhat more rapidly than total population during most of the projection period. This mostly reflects increased female participation in the labor force — which is associated with the relatively low fertility rates underlying the medium projection.[5] The age structure is also important, however, and changes in the distribution by age classes are expected to result in a fairly sharp decline in the rate of growth in the labor force after 2010.

In addition to the size of the labor force, the average number of hours worked per year has a substantial impact on the gross national product and on demand for most kinds of outdoor recreation. Historical trends in the hours worked per year show a slow decline that is projected to continue through 2030. Although the decline is slow, the average number of hours worked per year in 2030 is projected to be some 317 hours below the 1975 average, the equivalent of about eight 40-hour weeks.

[5] The alternative assumptions of fertility rates underlying the low and high population projections result in substantial differences in the rate of growth in the labor force. The highest rates of growth would be associated with the low population projection because, with the associated low fertility rates, more females would be free to join the labor force. Conversely, the lowest rate of growth in the labor force would be with the high population projection and the associated high fertility rates.

Gross National Product

In recent decades, changes in the consumption of most forest and range land products have been closely associated with changes in the Nation's gross national product.

Between 1929 and 1977, the gross national product, measured in constant 1972 dollars, increased more than four times — rising at an average annual rate of 3.1 percent (table 1.1, fig. 1.2). Annual changes have fluctuated widely, from as much as +16.0 percent to −14.7 percent. The highest sustained rate of growth in gross national product occurred in the 1960's, when it averaged 4.3 percent per year.

The wide fluctuations in annual rates of growth in the gross national product have reflected factors such as differences in the rates of change in labor force, rates of unemployment, hours worked per year, and productivity. These factors will presumably continue to cause fluctuations in the years ahead. But for this Assessment, only trends in growth were considered, and projections were based on the following assumed rates of increase:

(*Percent*)

Period	*Low*	*Medium*	*High*
1977-89	3.2	3.7	4.2
1990-99	2.2	2.7	3.2
2000-09	2.0	2.5	3.0
2010-19	1.5	2.0	2.5
2020-29	1.6	2.1	2.6

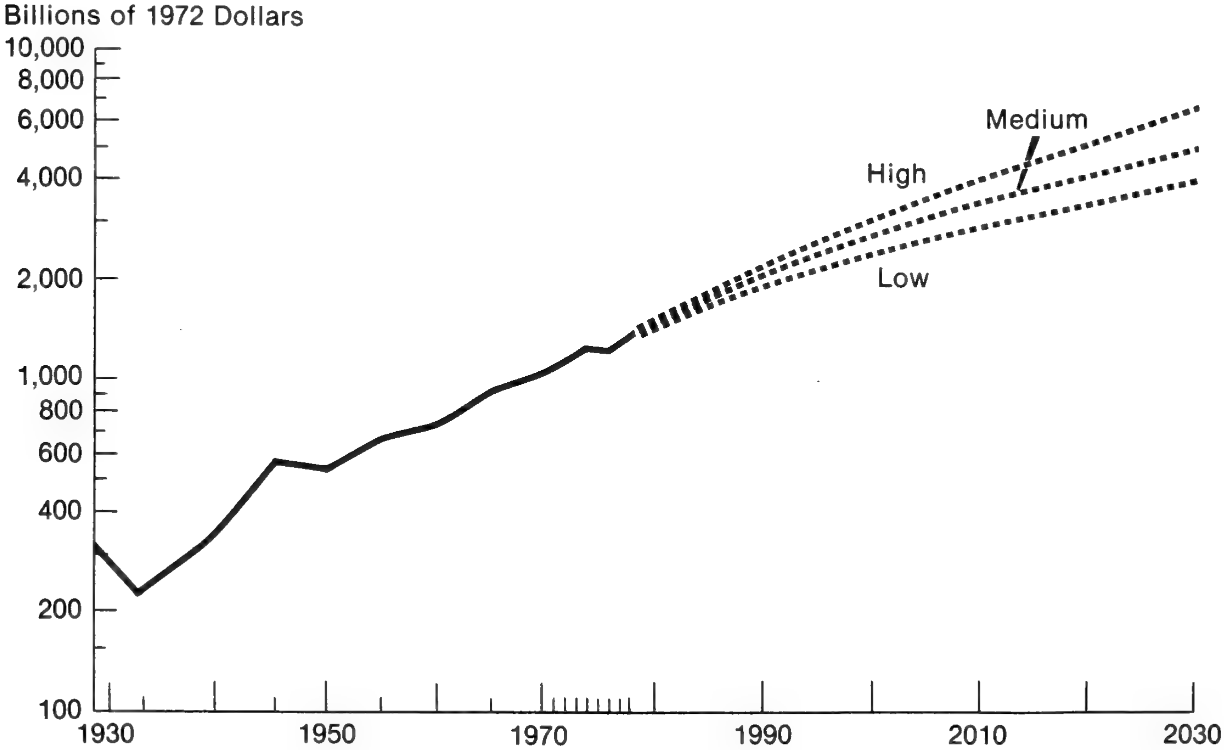
The assumed medium rates for the decades beyond the 1970's are based upon projections of the Bureau of Economic Analysis.[6] These in turn are partly based upon the medium projections of population and the associated projections of labor force and hours worked per year. The low and high rates are Forest Service assumptions which are chosen to display a range over which growth rates are likely to vary.

The medium assumed rate of growth would result in a gross national product of $2,690 billion (1972

[6] U.S. Department of Commerce, Bureau of Economic Analysis. Unpublished data. 1979.

Figure 1.2

Gross National Product 1929-77, with Projections to 2030



dollars) in 2000 — some two times that of 1977 (table 1.1). By 2030, this projection would reach $5,160 billion — some four times that of 1977. The associated projection of per capita gross national product in 2030 rises to $17,180 — nearly three times the 1977 average.

The detailed projections of gross national product by industry, prepared by the Bureau of Economic Analysis, indicate that the proportion of the gross national product originating in manufacturing and construction activity declines slowly over the projection period. Transportation, trade, and other services account for a slowly growing share of the total. These changes are consistent with long-established trends.

Even though there is some decline in their relative importance, the projected increases in manufacturing and construction are big. This means that the U.S. economy will continue to produce huge quantities of physical goods. In turn, large supplies of energy, minerals, and other raw materials will be needed to produce those goods.

The future adequacy of supplies of raw materials, and especially energy, is a matter of widespread concern. Concern is also evident about the ways the various programs designed to protect or improve the environment will affect the kinds of goods produced, person-hour productivity, and various other factors which determine the rate of growth in economic activity. Of course, no one knows how things will work out. Up to this time, economic activity has continued to increase much as it has in the recent past. Thus it appears that the economic growth assumptions adopted provide an acceptable basis for evaluating future demands for forest and range land products, and as a partial basis for guiding management policies and programs during the next several years. After that, and as required by the Forest and Rangeland Renewable Resources Planning Act, the outlook will be reevaluated and new expectations on economic growth incorporated in the 1990 Renewable Resource Assessment.

Disposable Personal Income

Disposable personal income, i.e., the income available for spending or saving by the Nation's population, has been another important determinant of the demand for certain products, such as many types of recreation, red meat, and various grades of paper and board. It also influences household formation, size of dwellings, and furniture consumption — which influence the demand for lumber and other timber products.

Since 1929, disposable personal income has equaled about 70 percent of the gross national product. This historical and rather constant relationship was assumed to continue through the projection period (table 1.1).

The resulting estimates (medium level) show per capita disposable personal income rising to $12,020 by 2030 (1972 dollars), nearly three times the 1977 average. This growth means that the Nation is faced not only with the task of meeting the resource demands of an additional 81 million people, but also the demands of 300 million people with much greater purchasing power than today's population.

Institutional and Technological Change

In the past, institutional and technological changes have substantially influenced use of renewable resources. Increasing urbanization, for example, has led to increased demand for some types of outdoor recreation and been an important source of the intensifying concern about the environment. It has also caused important shifts in the use of raw materials, including the partial displacement of timber products by steel, concrete, and other materials suitable for use in large urban structures.

Technological changes have also affected the demand for certain resources. For example, the development of freeze-dried foods and camping equipment has been important in the rapid growth in the recreational use of wilderness and backcountry areas. The development of economical water-resistant adhesives for exterior grades of plywood led to huge increases in plywood use, and was a major factor in holding down the consumption of lumber for roughly two decades. Similarly, new technology has led to large increases of hardwood lumber in pallets and of panel products such as hardboard and particleboard in a wide variety of end uses. On the other hand, recent developments in the pulp industry have substantially reduced the amount of water required to produce a ton of wood pulp. Innovations in the metals and plastics industries have resulted in displacement of lumber and plywood in such products as furniture and containers.

At any time, potential institutional and technological changes on the horizon could affect the demand for renewable resources. But the nature and effect of many of these potential changes are similar to those that have taken place in the past and that are accounted for in the use of historical data in preparing the projections.

A recent development not adequately reflected in the historical data base is the growing constraints on

the extractive, manufacturing, and energy industries to satisfy environmental and health objectives. This development is certain to have major implications for the projection period. Although it is too early to define the changes that will actually take place and their overall impacts with any certainty, such constraints have been taken into account in projecting economic activity and demands and supplies of renewable resources.

A related development, the reservation of forest and range lands for designated uses such as wilderness, parks, and wildlife refuges, has been going on for a long time; this development is specifically taken into account in the projections of forest and range land areas.

Energy Costs

Changes in energy costs have substantial effects on the demand for forest and range land products, both through their impact on the level of economic activity[7] and through their direct impact on the use of forest and range land products.[8]

The unit cost of energy minerals, which today accounts for the bulk of United States energy production, decreased steadily from about 1870 to the late 1960's.[9] Since then, however, there have been very large increases in energy prices, with the average relative price of crude oil in the United States more than doubling, and the price of coal and natural gas also doubling. At the same time, dependence on relatively high-cost imported crude oil and petroleum products has also grown rapidly.

A long historical period has obviously ended. During that time, improvements in technology offset the increase in costs as energy materials were used to process lower quality and less accessible resources. Many of the remaining petroleum reserves are concentrated in areas such as interior Alaska, the Arctic, and the outer continental shelf where the physical environment is severe and where development, operating, and transportation costs are high. Production of oil from shale and tar sands, which may begin before the end of this century, will entail very high development costs. In recent years, programs to protect the environment have also added to energy costs.

In summary, it seems fairly clear that the use of increasingly high-cost energy reserves, the removal of remaining controls on natural gas and second-tier oil prices, and added environmental protection costs are likely to push energy prices still higher relative to the general price level. At this time, there are no authoritative and generally accepted estimates of the size of the future increases. It does seem, however, that substantial and persistent upward movement is in prospect. This has been taken into account in projecting demands and supplies for those products where the higher prices can be expected to have a significant effect.

Capital Availability

Large amounts of capital will be required to make the necessary investments in management, physical facilities, and processing plants to accommodate increased demands for forest and range land resources. Far larger amounts of capital will be needed to make possible the levels of overall economic growth that are projected in this chapter. It is reasonable to ask whether such vast amounts of capital will be available to develop new energy sources, meet environmental protection requirements, provide for general economic activity, and meet the requirements for forest and range land resources. However, when capital requirements are required with past investment rates in the United States and western European

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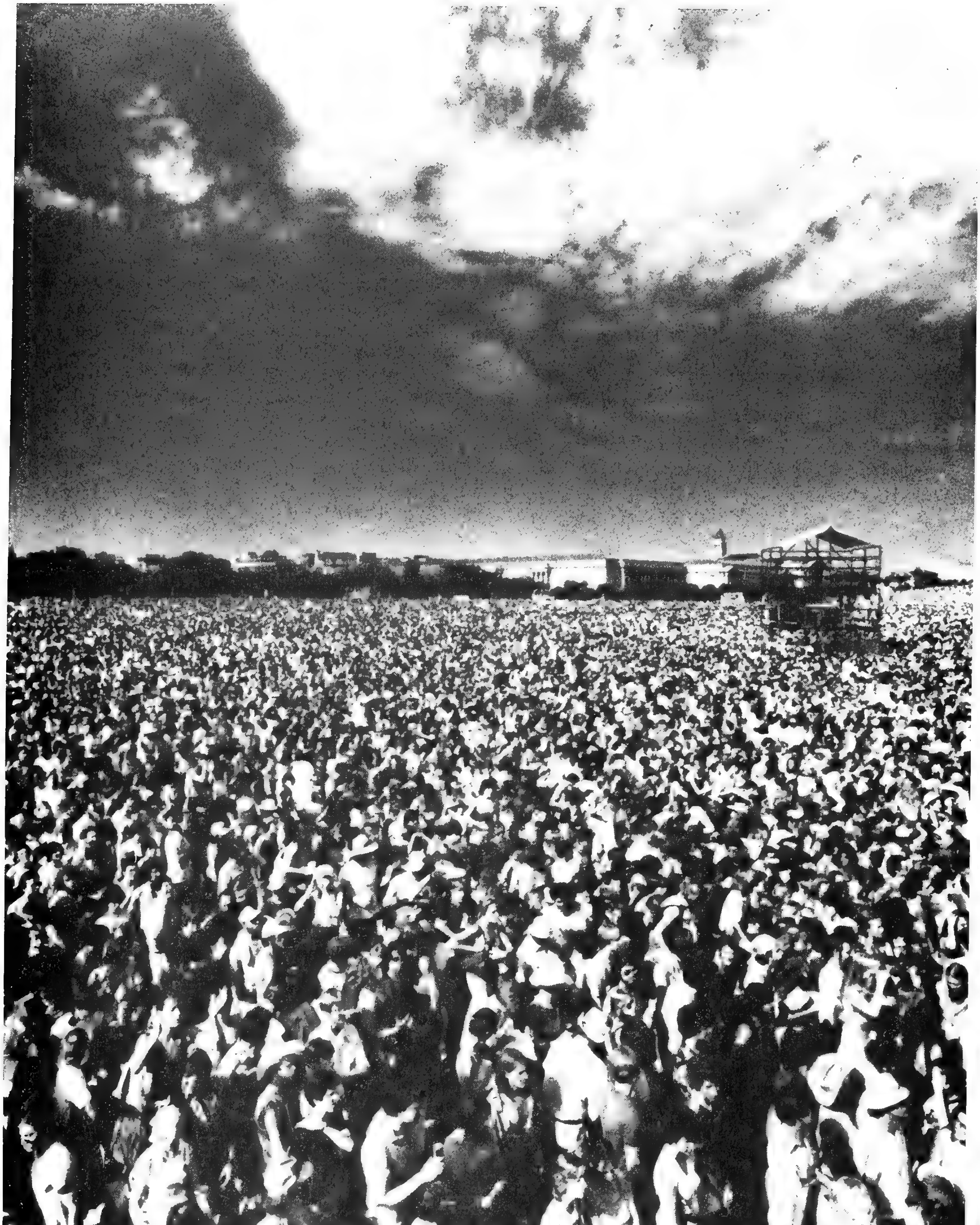
[7] *Edward Fried and Charles Schultze* (In *Higher oil prices and the world economy*. The Brookings Institution. Washington, D.C. 1974 p. 47, 54) estimated that the increase in world oil prices will result in a decrease in aggregate demand in the United States of 0.4 percent in 1980 and that these higher prices will reduce the rate of economic growth by 0.1 to 0.2 percent in the early 1980's. Edward Denison (In *Effects of selected changes in the institutional and human environment upon output per unit of input*. Survey of Current Business. U.S. Department of Commerce. January, 1978 p. 2144) stated that pollution abatement regulations have substantially lowered the rate of increase in output per unit of input in the United States and that the effect of these regulations is becoming more pronounced. He estimated that output in the nonresidential business sector in 1975 was 1.0 percent smaller than it would have been without such pollution abatement regulations.

[8] The estimates by Fried and Schultze of the effect of higher oil prices (see footnote 7) were for the U.S. economy as a whole. There are no comparable estimates of the impacts of recent increases in energy prices on the use of renewable natural resources. However, it is evident that there will be a tendency to increase use of those renewable resources that require relatively little energy in use and processing at the expense of substitute resources that require relatively large amounts of energy, and vice versa. For example, lumber and plywood are likely to be substituted to some extent for steel and concrete, which have heavy energy requirements in processing. On the other hand, demand for those kinds of outdoor recreation that require long-distance travel may be dampened somewhat by higher travel costs that result from higher energy prices.

[9] Harold Barnet and Chandler Mose (In *Scarcity and growth*. The Johns Hopkins Press 1963. p. 164-201) show that the unit cost of energy minerals declined from 1870 to 1957. Data for recent years show a continuation of this downward trend in relative energy prices until 1969. See, for example, The New York Times National Economic Survey, January 8, 1978.



countries, and with expected growth in gross national product, future requirements for capital do not appear particularly imposing.[10] It has, therefore, been assumed that capital availability will not significantly constrain long-term economic growth in general or intensified use of forest and range lands and the production of renewable resources products.

[10] At current levels of gross national product, a 1 percent increase in the rate of annual investment would yield about 20 billion dollars of additional capital. Such an increase is well within the range of experience of the United States and western European countries. See, for example, Edward F. Denison (*In* Why growth rates differ. The Brookings Institution. Washington, D.C. 1967, p. 117-120) and Barry Bosworth. (*In* Hearings on long-term economic growth) Joint Economic Committee. U.S. Congress. November 16, 1976, p. 109.

Other Assumptions

In addition to the general assumptions outlined above, the projections of demands and supplies for the products included in this document rest on a variety of other specified and implied assumptions. The most important are described in the appropriate places in the chapters that follow. Such assumptions include those on prices, changes in commercial timberland and rangeland areas, management intensities, the continuation of past relationships between variables, and constraints on the supplies of renewable resources associated with multiple-use management.

Chapter 2. — Forest and Range Lands

This chapter contains information on the area, characteristics, ownership, and use of the Nation's forest and range lands and associated waters. These lands and waters cover some 1.7 billion acres — nearly 70 percent of the total area in the United States (table 2.1, fig. 2.1). They provide not only tangible resources such as wood, water, wildlife, and forage, but also intangibles such as scenery and opportunities for outdoor recreation and study.

The Nation's forest and range lands and associated waters are diverse and complex encompassing a wide variety of characteristics, ownerships, productive capabilities, and uses. This chapter gives a brief national overview of that diversity and complexity and then describes the forest and range land and water base of each of four major geographic sections —North, South, Rocky Mountains and Great Plains, and Pacific Coast (see frontispiece).

The resource base for this Assessment has been divided into three major categories: forest land, rangeland, and water areas (table 2.1).

Forest land is land at least 10 percent stocked by forest trees of any size, including land that formerly had such tree cover and that will be naturally or artificially reforested. Included in these lands are transition zones, such as areas between heavily forested and nonforested lands that are at least 10 percent stocked with forest trees, and forest areas adjacent to urban and built-up lands.

Rangeland is land on which the potential natural vegetation is predominantly grasses, grass-like plants, forbs, or shrubs; including land revegetated naturally or artificially that is managed like native vegetation. Rangeland includes natural grasslands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows, that are less than 10 percent stocked with forest trees of any size.

The forest and range land data in this Assessment may differ from those in other reports, due to differences in definitions. For example, the pinyon-juniper and chaparral plant communities of the western United States, classed as forest ecosystems herein, are sometimes counted as rangelands due to their forage values. The transition zone between forest and nonforest is considered forest here, but rangeland in some studies. The urban fringe forests are included as forest in the report, but other reports have classified them as nonforest.

Water areas are divided into several categories. Large inland water areas are lakes, ponds, and reservoirs at least 40 acres in size and streams and rivers at least one-eighth of a mile wide. Small water areas include lakes and ponds that are at least 2 acres but less than 40 acres in size, and rivers and streams at least 120 feet wide but less than one-eighth of a mile. Other water includes the Great Lakes, and the estuaries of the contiguous States, but excludes the estuaries of Alaska and Hawaii.

Overview

Vegetative Cover

The vegetative cover on the 1.6 billion acres of forest and range land in the United States varies greatly from one part of the country to another. The basic vegetative cover largely determines the uses that can be made of the land and is directly related to annual precipitation. In the areas of the Nation that receive substantial moisture throughout the year, the dominant vegetative cover is forests. In arid and semiarid areas, the dominant cover is grasses and shrubs typically associated with rangelands.

The total forest and range land base of the Nation is almost evenly divided between the two categories, 820 million acres of rangeland and 736 million acres of forests. In addition, there are 698 million acres of cropland, improved pasture, developed, or barren land (table 2.1).

Most of the Nation's rangelands are found in the Great Plains, the western United States, and Interior Alaska (fig. 2.2). Rangelands occupy more than 50 percent of the total land area in each of eight States: Alaska, Arizona, Montana, Nevada, New Mexico, Texas, Utah, and Wyoming. These States together account for more than 45 percent of the Nation's total rangeland base.

The States east of the Great Plains generally support either a highly developed agricultural economy or are heavily forested. They account for only 13 percent of the Nation's rangeland.

Forest land, unlike rangeland, is distributed widely in both the eastern and western United States (fig. 2.3). The land east of the Great Plains that has not been cleared for agriculture is usually heavily forested. In addition, humid portions of the Pacific Coast and high elevation areas in the West that receive adequate precipitation are also forested. The eastern States account for slightly more than half of the Nation's forest land while the Rocky Mountain and Pacific Coast States account for most of the remainder. The Great Plains States have relatively little forest land.

Vegetative cover on the Nation's forests and rangelands is diverse as a result of differences in climate, topography, and soils. The classification system for forests and for rangelands used in this Assessment is

Table 2.1—*Land and water areas of the United States, by class of land, water, and section, region, and State*[1]

(Thousand acres)

Section, region, and State	Total land and water area	Land: Total land area	Land: Total forest and range land	Land: Forest and range land: Forest[2]	Land: Forest and range land: Range-land[3]	Land: Other land[4]	Water: Total water area	Water: Inland water: Total inland water	Water: Inland water: Large area[5]	Water: Inland water: Small area[6]	Water: Other water[7]
North:											
Northeast:											
Connecticut	3,572.7	3,081.7	1,860.8	1,860.8	0.0	1,220.9	491.0	124.0	93.0	31.0	367.0
Delaware	1,540.5	1,232.5	391.8	391.8	.0	840.7	308.0	84.0	72.0	12.0	224.0
Maine	21,963.2	19,729.2	17,718.	17,718.3	.4	2,010.5	2,234.0	1,529.0	1,415.0	114.0	705.0
Maryland	7,874.2	6,289.2	2,736.9	2,653.2	83.7	3,552.3	1,585.0	480.0	439.0	41.0	1,105.0
Massachusetts	5,898.6	5,006.6	2,952.4	2,952.3	.1	2,054.2	892.0	278.0	233.0	45.0	614.0
New Hampshire	5,954.3	5,731.3	5,013.5	5,013.5	.0	717.8	223.0	223.0	177.0	46.0	.0
New Jersey	5,261.4	4,775.4	1,988.9	1,928.4	60.5	2,786.5	486.0	240.0	205.0	35.0	246.0
New York	34,531.6	30,356.6	17,220.2	17,218.4	1.8	13,136.4	4,175.0	1,374.0	1,136.0	238.0	2,801.0
Pennsylvania	29,483.2	28,592.2	16,826.0	16,825.9	.1	11,766.2	891.0	421.0	268.0	153.0	470.0
Rhode Island	786.4	664.4	404.2	404.2	.0	260.2	122.0	113.0	105.0	8.0	9.0
Vermont	6,149.9	5,906.9	4,511.9	4,511.7	.2	1,395.0	243.0	243.0	219.0	24.0	.0
West Virginia	15,475.8	15,334.8	11,668.6	11,668.6	.0	3,666.2	141.0	141.0	71.0	70.0	.0
Total	138,491.8	126,700.8	83,293.9	83,147.1	146.8	43,406.9	11,791.0	5,250.0	4,433.0	817.0	6,541.0
North Central:											
Illinois	37,072.7	35,441.7	3,810.7	3,810.4	.3	31,631.0	1,631.0	654.0	435.0	219.0	977.0
Indiana	23,370.1	22,951.1	3,946.0	3,942.9	3.1	19,005.1	419.0	273.0	135.0	138.0	146.0
Iowa	36,025.2	35,634.2	1,599.7	1,561.3	38.4	34,034.5	391.0	391.0	198.0	193.0	.0
Michigan	61,946.5	36,172.5	19,270.8	19,270.4	.4	16,901.7	25,774.0	1,086.0	894.0	192.0	24,688.0
Minnesota	55,288.0	50,382.0	16,865.0	16,709.2	155.8	33,517.0	4,906.0	3,490.0	3,106.0	384.0	1,416.0
Missouri	44,598.8	43,867.8	14,323.6	12,876.0	1,447.6	29,544.2	731.0	731.0	473.0	258.0	.0
Ohio	28,683.0	26,121.0	6,146.6	6,146.6	.0	19,974.4	2,562.0	350.0	173.0	177.0	2,212.0
Wisconsin	42,379.0	34,616.0	14,914.7	14,907.7	7.0	19,701.3	7,763.0	1,323.0	1,095.0	228.0	6,440.0
Total	329,363.3	285,186.3	80,877.1	79,224.5	1,652.6	204,209.2	44,177.0	8,298.0	6,509.0	1,789.0	35,879.0
Total, North	467,855.1	411,887.1	164,171.0	162,371.6	1,799.4	247,716.1	55,968.0	13,548.0	10,942.0	2,606.0	42,420.0
South:											
Southeast:											
Florida	38,588.6	33,993.6	19,228.8	17,039.7	2,189.1	14,764.8	4,595.0	3,485.0	3,006.0	479.0	1,110.0
Georgia	37,711.7	36,795.7	25,256.0	25,256.0	.0	11,539.7	916.0	885.0	521.0	364.0	31.0
North Carolina	33,654.7	30,955.7	20,043.3	20,043.3	.0	10,912.4	2,699.0	2,699.0	2,449.0	250.0	.0
South Carolina	19,963.0	19,143.0	12,269.4	12,249.4	20.0	6,873.6	820.0	732.0	569.0	163.0	88.0
Virginia	27,090.2	25,286.2	16,444.9	16,417.4	27.5	8,841.3	1,804.0	837.0	657.0	180.0	967.0
Total	157,008.2	146,174.2	93,242.4	91,005.8	2,236.6	52,931.8	10,834.0	8,638.0	7,202.0	1,436.0	2,196.0
South Central:											
Alabama	33,388.1	32,231.1	21,415.1	21,361.1	54.0	10,816.0	1,157.0	799.0	597.0	202.0	358.0
Arkansas	33,986.6	33,090.8	18,281.7	18,281.5	.2	14,809.1	896.0	896.0	686.0	210.0	.0
Kentucky	25,853.0	25,282.0	12,160.8	12,160.8	.0	13,121.2	571.0	571.0	454.0	117.0	.0
Louisiana	31,705.2	28,409.2	15,074.7	14,558.1	516.6	13,334.5	3,296.0	2,646.0	2,309.0	337.0	650.0
Mississippi	30,953.7	29,929.7	16,735.3	16,715.6	19.7	13,194.4	1,024.0	668.0	313.0	355.0	356.0
Oklahoma	44,748.8	43,727.8	17,814.2	8,513.3	9,300.9	25,913.6	1,021.0	1,021.0	828.0	193.0	.0
Tennessee	27,035.9	26,289.9	13,560.9	13,160.5	400.4	12,729.0	746.0	746.0	633.0	113.0	.0
Texas	171,149.8	167,282.8	114,878.1	23,279.3	91,598.8	52,404.7	3,867.0	3,814.0	3,315.0	499.0	53.0
Total	398,821.3	386,243.3	229,920.8	128,030.2	101,890.6	156,322.5	12,578.0	11,161.0	9,135.0	2,026.0	1,417.0
Total, South	555,829.5	532,417.5	323,163.2	219,036.0	104,127.2	209,254.3	23,412.0	19,799.0	16,337.0	3,462.0	3,613.0
Rocky Mountain and Great Plains:											
Rocky Mountain:											
Arizona	72,902.3	72,580.3	63,662.2	18,493.9	45,168.3	8,918.1	322.0	322.0	314.0	8.0	.0
Colorado	66,720.1	66,283.1	50,092.7	22,271.0	27,821.7	16,190.4	437.0	437.0	311.0	126.0	.0
Idaho	53,476.1	52,676.1	45,324.7	21,726.6	23,598.1	7,351.4	800.0	800.0	737.0	63.0	.0
Montana	94,168.2	92,896.2	75,893.3	22,559.3	53,334.0	17,002.9	1,272.0	1,272.0	1,040.0	232.0	.0
Nevada	70,739.8	70,294.8	64,571.0	7,683.3	56,887.7	5,723.8	445.0	445.0	428.0	17.0	.0
New Mexico	77,864.0	77,669.0	66,785.3	18,059.8	48,725.5	10,883.7	195.0	195.0	149.0	46.0	.0
Utah	54,343.7	52,504.7	45,258.4	15,557.4	29,701.0	7,246.3	1,841.0	1,841.0	1,809.0	32.0	.0
Wyoming	62,666.3	62,055.3	56,924.5	10,028.3	46,896.2	5,130.8	611.0	611.0	525.0	86.0	.0
Total, Rocky Mountain	552,882.5	546,959.5	468,512.1	136,379.6	332,132.5	78,447.4	5,923.0	5,923.0	5,313.0	610.0	.0

See footnote at end of table.

Table 2.1—*Land and water areas of the United States, by class of land, water, and section, region, and State*[1]—continued

(Thousand acres)

Section, region, and State	Total land and water area	Land: Total land area	Land: Total forest and range land	Land: Forest and range land: Forest[2]	Land: Forest and range land: Range-land[3]	Land: Other land[4]	Water: Total water area	Water: Inland water: Total inland water	Water: Inland water: Large area[5]	Water: Inland water: Small area[6]	Water: Other water[7]
Great Plains:											
Kansas	52,648.7	52,126.7	17,622.6	1,344.4	16,278.2	34,504.1	522.0	522.0	295.0	227.0	.0
Nebraska	49,425.1	48,828.1	25,303.5	1,029.1	24,274.4	23,524.6	597.0	597.0	451.0	146.0	.0
North Dakota	45,225.7	43,938.7	12,717.7	421.8	12,295.9	31,221.0	1,287.0	1,287.0	923.0	364.0	.0
South Dakota	49,310.2	48,381.2	25,099.7	1,702.0	23,397.7	23,281.5	929.0	929.0	743.0	186.0	.0
Total, Great Plains	196,609.7	193,274.7	80,743.5	4,497.3	76,246.2	112,531.2	3,335.0	3,335.0	2,412.0	923.0	.0
Total, Rocky Mountain and Great Plains	749,492.2	740,234.2	549,255.6	140,876.9	408,378.7	190,978.6	9,258.0	9,258.0	7,725.0	1,533.0	.0
Pacific Coast:											
Pacific Northwest:											
Alaska	375,303.0	362,485.0	350,616.5	119,144.9	231,471.6	11,868.5	12,818.0	12,818.0	12,787.0	31.0	.0
Oregon	62,099.0	61,356.0	52,132.7	29,810.0	22,322.7	9,223.3	743.0	712.0	606.0	106.0	31.0
Washington	45,177.0	42,456.0	31,076.0	23,181.0	7,895.0	11,380.0	2,721.0	1,187.0	1,039.0	148.0	1,534.0
Total	482,579.0	466,297.0	433,825.2	172,135.9	261,689.3	32,471.8	16,282.0	14,717.0	14,432.0	285.0	1,565.0
Pacific Southwest:											
California	101,607.0	99,847.0	83,191.7	40,152.0	43,039.7	16,655.3	1,760.0	1,716.0	1,489.0	227.0	44.0
Hawaii	4,128.0	4,109.0	2,954.0	1,986.0	968.0	1,155.0	19.0	19.0	16.0	3.0	.0
Total	105,735.0	103,956.0	86,145.7	42,138.0	44,007.7	17,810.3	1,779.0	1,735.0	1,505.0	230.0	44.0
Total, Pacific Coast	588,314.0	570,253.0	519,970.9	214,273.9	305,697.0	50,282.1	18,061.0	16,452.0	15,937.0	515.0	1,609.0
Total, United States	2,361,490.8	2,254,791.8	1,556,560.7	736,558.4	820,002.3	698,231.1	106,699.0	59,057.0	50,941.0	8,116.0	47,642.0

[1]Data for forest land as of January 1, 1977; data for rangeland and other land as of 1976; data on inland water as of 1977; data on other water as of 1970.

[2]Land at least 10 percent stocked by forest trees of any size, or formerly having such cover, and not currently developed for nontimber use. Included in these lands are transition zones, such as areas between heavily forested and non-forested lands and forest areas adjacent to urban built-up lands, which may have timber production as a primary use.

[3]Land on which the natural vegetation is predominately grasses, grasslike plants, forbs, or shrubs; and which is not currently developed for nonrange use.

[4]Residual obtained by subtracting forest land and rangeland from total land area. This category includes cropland, improved pasture, and industrial and urban areas.

[5]Lakes and ponds at least 40 acres in size; waterways ⅛ mile or more in width.

[6]Lakes and ponds between 2 and 40 acres in size; waterways less than ⅛ mile in width.

[7]Includes Atlantic, Pacific, and Gulf Coastal waters: Chesapeake and Delaware Bays; Long Island and Puget Sounds: New York Harbor; Straits of Juan de Fuca and Georgia; and the Great Lakes. Excludes Alaska and Hawaii.

Sources: Forest land — U.S. Department of Agriculture, Forest Service. *Forest Statistics of the U.S. 1977.*

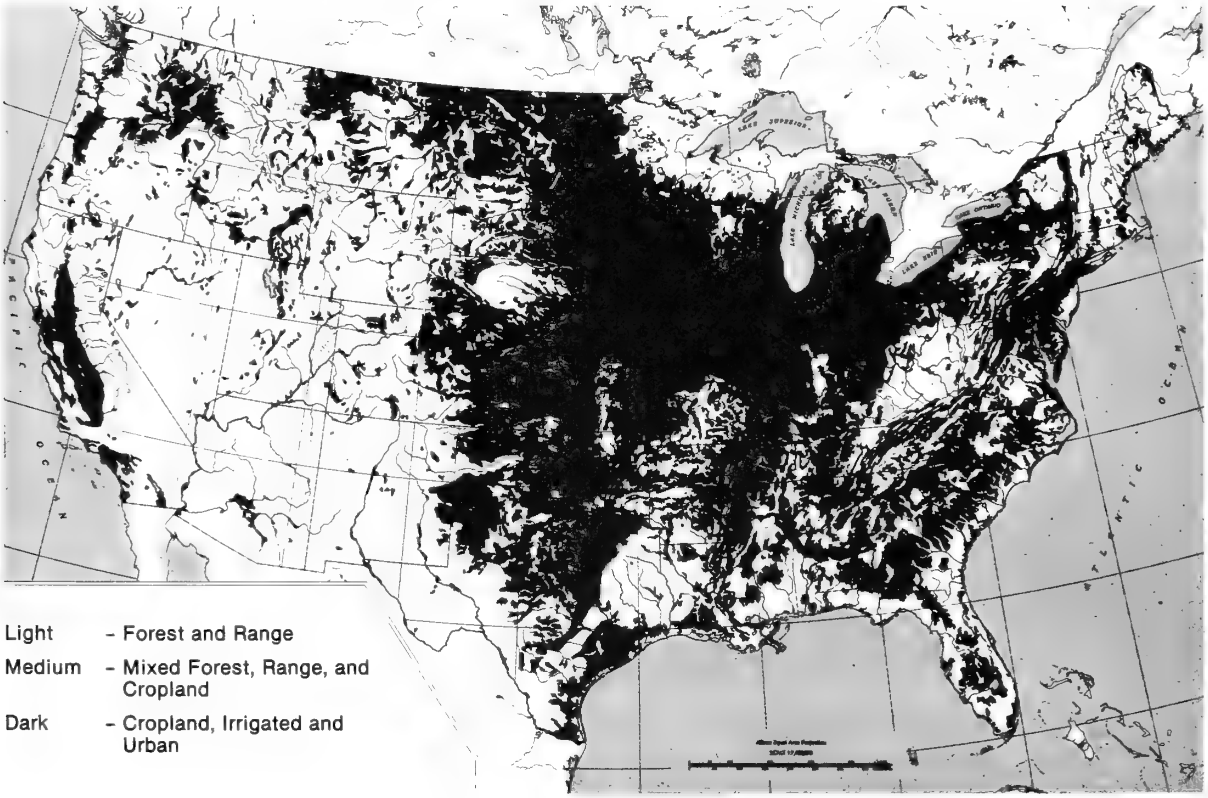
Rangeland — U.S. Department of Agriculture, Forest Service estimates based on data supplied by U.S. Department of Agriculture, Soil Conservation Service U.S. Department of the Interior, Bureau of Land Management, Bureau of Indian Affairs, and National Park Service; and U.S. Department of Defense.

Inland water — U.S. Department of Agriculture, Soil Conservation Service (preliminary data)

All other land and water. U.S. Department of Commerce, Bureau of Census. Area Measurement Reports. GE-20 No. 1, 22 p. 1970.

Figure 2.1

Forest and Range Land Areas in the Contiguous United States



based on vegetation. Closely related plant communities have been aggregated into single ecosystems. Forest ecosystems are synonymous with forest cover types developed and defined in the Forest Survey conducted by the Forest Service.[1] Rangeland ecosystems are based on potential natural plant communities termed phytocoenoses.[2] Detailed descriptions of each ecosystem can be found in "Vegetation and Environmental Features of Forest and Range Ecosystems."[3]

[1] U.S. Department of Agriculture, Forest Service Geographic forest types used in the forest survey. For. Serv. Handbk. 4813.1, sec. 74, March 1967.

[2] Kuchler, A. W. Potential natural vegetation of the conterminous United States. Am. Geogr. Soc. Spec. publ. no. 36, 116 p. with map. 1964.

Kuchler, A. W. Potential natural vegetation. Nat. Atlas of the U.S.A., U.S. Dep. of the Interior, Geol. Survey, p. 89-92. 1970.

[3] Garrison, George A., Ardell J. Bjugstad, Don A. Duncan, Mont E. Lewis, and Dixie R. Smith. Vegetation and environmental features of forest and range ecosystems. U.S. Department of Agriculture, Agric. Handbk. 475, 68 p. 1977.

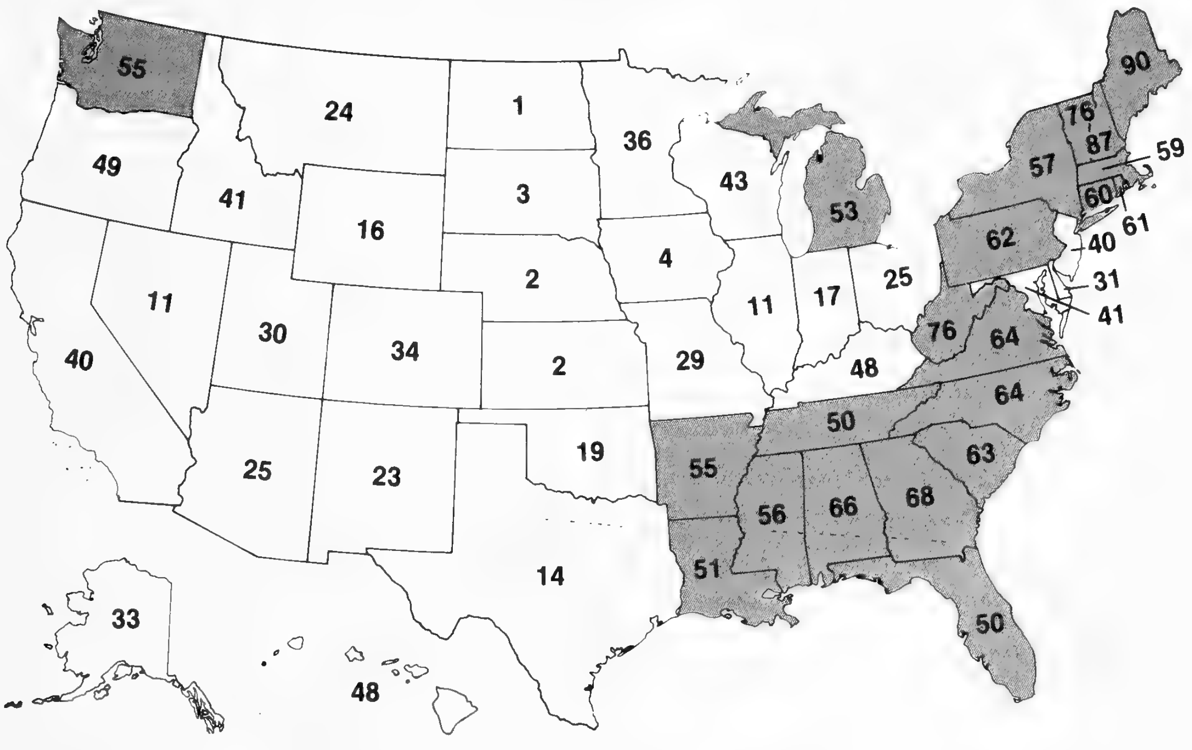
Trends in Area

The available data indicate that the area in forest and range land has been declining in recent decades. The inland water area, on the other hand, has been increasing mainly due to reservoir construction. These trends are expected to continue. For example, the total area of forest and range land is projected to be about 5 percent lower by 2030, with decreases of 2 percent for forest lands (from 736 to 718 million acres) and 7 percent for rangelands (from 820 to 764 million acres) (table 2.2).

During the 1980's, a significant portion of the projected decline in forest area is expected to result from conversion of forest to cropland, particularly on deltas and bottomlands of southern rivers. However, after 1990, reduction in forest land area will mainly result from conversion to other land uses such as reservoirs, urban expansion, highway and airport construction, and surface mining. As indicated in the

Figure 2.2

Forest Land as a Percentage of Total Land Area



discussion on mining later in this chapter, increased reclamation of mined lands in the future will limit the longrun impacts of surface mining on the total area of forest land.

The loss of 56 million acres of rangeland will occur largely on private lands, due to changes to cropland and developed uses such as residential sites, highways, airports, and mines. Some rangeland areas will be converted to improved pasture, which is an intensification, rather than a change, in land use. As with forests, required reclamation of mined lands will limit the longrun effects of surface mining on the total area of rangelands.

Ownership

About 54 percent of the Nation's present area of forest and range land is non-Federal ownership, which is mainly private, but also includes State and municipal lands (table 2.3). This proportion is changing due to State and Native selections of Federal lands in Alaska. After these selections of well over 100 million acres have been completed, the proportion of forest and range lands in non-Federal ownership will increase several percent.

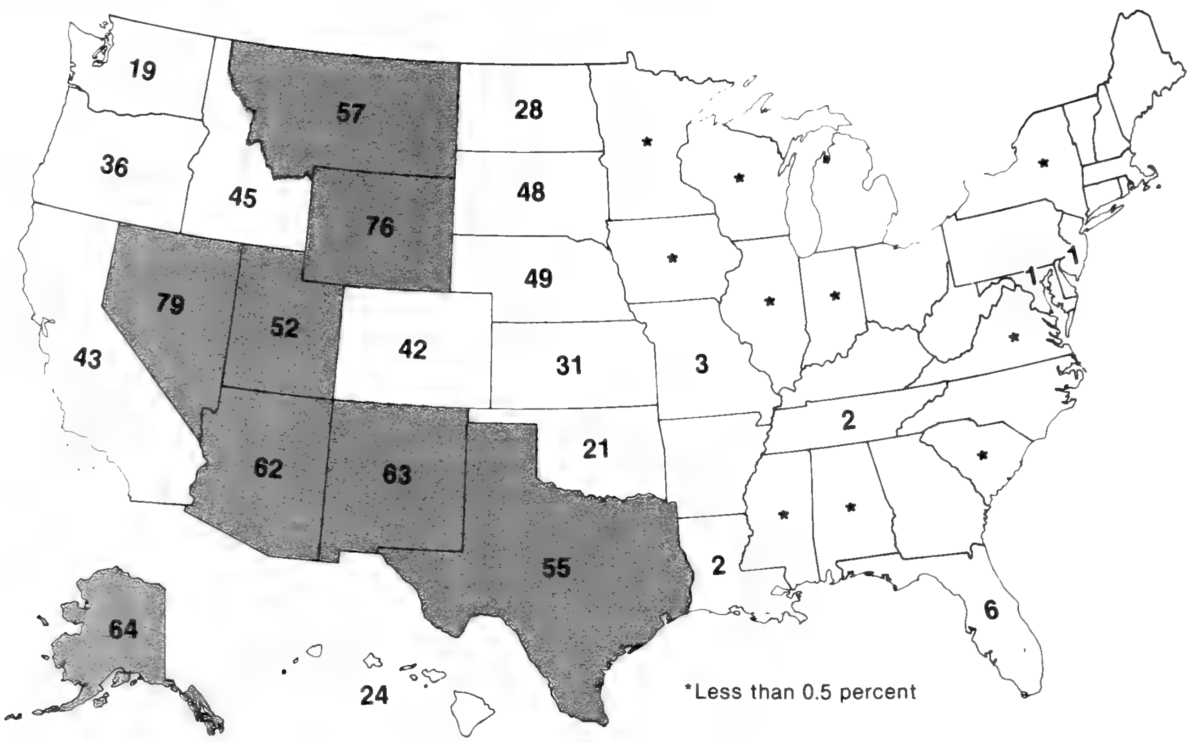
Forest and range lands under Federal jurisdiction in the contiguous States include 174 million acres administered by the Bureau of Land Management and 167 million acres of National Forest System lands. Other Federal forest and range lands, totaling only 45 million acres, are administered by various agencies in the Department of the Interior and the Department of Defense.

Of the 351 million acres of forest and range land in Alaska, 6 percent are National Forests, 81 percent are administered by the Bureau of Land Management, 9 percent are other Federal lands, and only 4 percent are non-Federal lands. The bulk of the State and Native selections of Federal lands in Alaska will come from lands administered by the Bureau of Land Management; however, most of the highly productive forest lands selected will come from National Forests.

Most of the eastern forest lands are State and privately owned. Federal ownership is heavily concentrated in the western forest and range land. Only 9 percent of the eastern forest lands are Federal, but 72

Figure 2.3

Rangeland as a Percentage of Total Land Area



percent of the western forest lands and 61 percent of the western rangelands are in Federal ownership (table 2.3). These proportions, too, will change somewhat as the selections in Alaska are made and title is transferred to the State and to Native groups.

Productivity

Productivity is a measure of the ability of land to produce timber, forage, wildlife, or other biological outputs. There is no single measure that adequately describes the productivity of forest and range lands for all of the products or outputs that can be obtained from them. Measures such as cubic feet or board feet of timber or pounds of forage produced per acre annually are often used as estimates of productivity. Although measures of productivity for other uses, such as wildlife or recreation, are not well developed, biological productivity as measured for timber and forage is often useful in helping to determine capacity for other uses.

A number of factors determine productivity for timber and forage. Chief among them are soil, climate, and topography. Thus, lands with arid climates, at high elevations or in northern latitudes, tend to have lower productivity for timber and forage than lands more favorably situated. However, an unfavorable situation for the production of timber or forage may in some cases be taken as an indicator of high productivity for some kinds of outdoor recreation.

The inherent productivity of forest and range lands can in many cases be altered by investments in intensive management. The productivity levels discussed in this chapter are the maximum potentials for forest and range ecosystems in the absence of such intensified management. Natural potentials have been used because they are available for most areas, and because they provide a uniform means of describing the relative productivity of the Nation's forests and rangelands.

Table 2.2 — *Land and water areas of the United States, by class of land and water, 1970, 1977, with projections to 2030*

(Million acres)

Class	1970	1977	Projections 1990	2000	2010	2020	2030
Land:							
Forest and range land:							
Forest land[1]	754	737	732	728	724	720	718
Rangeland[2]	819	820	808	796	785	776	764
Total	1,573	1,557	1,540	1,524	1,509	1,496	1,482
Other land[3]	686	697	711	724	737	749	761
Total	2,259	2,254	2,251	2,248	2,246	2,245	2,243
Water[4]	102	107	110	113	115	116	118
Total	2,361	2,361	2,361	2,361	2,361	2,361	2,361

[1]Land at least 10 percent stocked by forest trees of any size, or formerly having such cover, and not currently developed for nontimber use. Included in these lands are transition zones, such as areas between heavily forested and non-forested lands and forest areas adjacent to urban and built-up lands, which may not have timber production as a primary use.

[2]Land on which the natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs; and which is not currently developed for nonrange use.

[3]Other land includes cropland, improved pasture, industrial and urban land, and all other land categories except forest land and range land.

[4]Water area includes lakes and ponds over 2 acres in size, waterways, the Great Lakes and coastal waters and estuaries excluding Alaska and Hawaii.

For this Assessment, productivity of forest land is defined as the amount of wood per acre per year that can be produced in fully stocked natural stands. At the present time, the Nation's forest lands as a whole are capable of producing an average of 74 cubic feet of wood per acre per year. But such averages obscure some significant geographic differences. The two eastern sections of the country, for example, have an average productive potential of 65 and 77 cubic feet per acre per year, while the forest land in the Pacific Coast has an average annual productive potential of 97 cubic feet.

Even within a single section, there is a wide range of productivity. On the Pacific Coast, extensive areas in the Douglas-fir ecosystem are capable of producing over 200 cubic feet of wood per acre per year, but extensive areas of fir-spruce and pinyon-juniper cannot produce 20 cubic feet of wood per acre per year (tables 2.4 and 2.5).

Rangeland productivity is measured by annual production of herbage and browse per acre. Of the various categories of rangelands, wet grasslands have the highest inherent productivity, producing on the average over 5,100 pounds (air-dry) of herbage and browse per acre per year (table 2.6). The desert ecosystem produces practically no herbage and browse. The desert shrub and desert grasslands ecosystems are also low producers, averaging only 249 and 307 pounds, respectively. In general, grasslands have higher average productivity than do the shrublands.

Forest lands generally have a high potential for production of herbage and browse if they have little or only partial tree cover. For example, the redwood forest ecosystem is capable of producing an average of 4,800 pounds of herbage and browse per acre annually; the hemlock-sitka spruce ecosystem could average 4,200 pounds. Average potential production for most other forest lands is in the range of 1,000-2,000 pounds per acre.

It is unlikely that major areas of forest land will be cleared for use as rangeland, even though potential productivity is high. Some forest lands, especially the open-grown pine lands of the western United States, now produce considerable forage for domestic livestock; and most forest lands produce herbage and browse for deer and other wildlife. Forest stands can be managed to increase the production or availability of herbage and browse for livestock and wildlife, while continuing the production of timber. However, such management may lead to a reduction in timber production.

With the exception of southeast Alaska coastal forests, the Alaska forest land and rangeland ecosystems have generally lower productivity levels than counterpart ecosystems in the other States. The Hawaiian forest ecosystems have high inherent productivities for herbage and browse, well over 4,000 pounds per acre.

Table 2.3 — *Forest and range land areas in the United States, by ownership and section, region, and State, 1977*
(Thousand acres)

Section, region, and State	Total forest and range land					Forest land					Rangeland				
	Total	Ownership				Total	Ownership				Total	Ownership			
		Federal lands administered by			Non-Federal		Federal lands administered by			Non-Federal		Federal lands administered by			Non-Federal
		Forest Service	Bureau of Land Mgmt.	Other Federal			Forest Service	Bureau of Land Mgmt.	Other Federal			Forest Service	Bureau of Land Mgmt.	Other Federal	
North:															
Northeast:															
Connecticut	1,860.8	0.0	0.0	2.4	1,858.4	1,860.8	0.0	0.0	2.4	1,858.4	0.0	0.0	0.0	0.0	0.0
Delaware	391.8	.0	.0	5.0	386.8	391.8	0.0	.0	5.0	386.8	(1)	0.0	0.0	(1)	.0
Maine	17,718.7	51.5	.0	176.8	17,490.4	17,718.3	51.5	.0	176.4	17,490.4	.4	.0	.0	.0	.0
Maryland	2,736.9	.0	.0	160.8	2,576.1	2,653.2	.0	.0	155.0	2,498.2	83.7	.0	.0	5.8	77.9
Massachusetts	2,952.4	.0	.0	60.1	2,892.3	2,952.3	.0	.0	60.0	2,892.3	.1	.0	.0	.1	.0
New Hampshire	5,013.5	684.0	.0	12.6	4,316.9	5,013.5	684.0	.0	12.6	4,316.9	.0	.0	.0	.0	.0
New Jersey	1,988.9	.0	.0	94.1	1,894.8	1,928.4	.0	.0	93.6	1,834.8	60.5	.0	.0	.5	60.0
New York	17,220.2	13.3	.0	188.2	17,018.7	17,218.4	13.3	.0	186.4	17,018.7	1.8	.0	.0	1.8	.0
Pennsylvania	16,826.0	506.4	.0	50.7	16,268.9	16,825.9	506.4	.0	50.6	16,268.9	.1	.0	.0	.1	.0
Rhode Island	404.2	.0	.0	7.0	397.2	404.2	.0	.0	7.0	397.2	.0	.0	.0	.0	.0
Vermont	4,511.9	261.6	.0	13.4	4,236.9	4,511.7	261.6	.0	13.2	4,236.9	.2	.0	.0	.2	.0
West Virginia	11,668.6	960.8	.0	39.1	10,668.7	11,668.6	960.8	.0	39.1	10,668.7	.0	.0	.0	.0	.0
Total	83,293.9	2,477.6	.0	810.2	80,006.1	83,147.1	2,477.6	.0	801.3	79,868.2	146.8	.0	.0	8.9	137.9
North Central:															
Illinois	3,810.7	256.0	.0	84.4	3,470.3	3,810.4	256.0	.0	84.1	3,470.3	.3	.0	.0	.3	.0
Indiana	3,946.0	180.4	.0	187.0	3,578.6	3,942.9	180.4	.0	183.9	3,578.6	3.1	.0	.0	3.1	.0
Iowa	1,599.7	.0	.0	64.6	1,535.1	1,561.3	.0	.0	55.2	1,506.1	38.4	.0	.0	9.4	29.0
Michigan	19,270.8	2,701.6	8.4	657.2	15,903.6	19,270.4	2,701.6	8.4	656.8	15,903.6	.4	.0	.0	.4	.0
Minnesota	16,865.0	2,785.1	9.5	283.2	13,787.2	16,709.2	2,785.1	9.5	195.5	13,719.1	155.8	.0	.0	87.7	68.1
Missouri	14,323.6	1,453.8	.0	137.3	12,732.5	12,876.0	1,279.0	.0	135.3	11,461.7	1,447.6	174.8	.0	2.0	1,270.8
Ohio	6,146.6	166.6	.0	39.1	5,940.9	6,146.6	166.6	.0	39.1	5,940.9	.0	.0	.0	.0	.0
Wisconsin	14,914.7	1,492.6	.0	156.1	13,266.0	14,907.7	1,492.6	.0	149.1	13,266.0	7.0	.0	.0	7.0	.0
Total	80,877.1	9,036.1	17.9	1,608.9	70,214.2	79,224.5	8,861.3	17.9	1,499.0	68,846.3	1,652.6	174.8	.0	109.9	1,367.9
Total, North	164,171.0	11,513.7	17.9	2,419.1	150,220.3	162.371.6	11,338.9	17.9	2,300.3	148,714.5	1,799.4	174.8	.0	118.6	1,505.8
South:															
Southeast:															
Florida	19,228.8	1,082.3	.2	1,433.9	16,712.4	17,039.7	1,082.3	.2	1,236.5	14,720.7	2,189.1	.0	.0	197.4	1,991.7
Georgia	25,256.0	856.2	.0	642.1	23,757.7	25,256.0	856.2	.0	642.1	23,757.7	.0	.0	.0	.0	.0
North Carolina	20,043.3	1,146.1	.0	679.2	18,218.0	20,043.3	1,146.1	.0	679.2	18,218.0	.0	.0	.0	.0	.0
South Carolina	12,269.4	607.2	.0	289.6	11,372.6	12,249.4	607.2	.0	289.6	11,352.6	20.0	.0	.0	.0	20.0
Virginia	16,444.9	1,602.8	.0	490.1	14,352.0	16,417.4	1,602.8	.0	478.6	14,336.0	27.5	.0	.0	11.5	16.0
Total	93,242.4	5,294.6	.2	3,534.9	84,412.7	91,005.8	5,294.6	.2	3,326.0	82,385.0	2,236.6	.0	.0	208.9	2,027.7

South Central:															
Alabama	21,415.1	640.0	.0	200.9	20,574.2	21,361.1	640.0	.0	199.7	20,521.4	54.0	.0	.0	1.2	52.8
Arkansas	18,281.7	2,464.8	1.1	303.0	15,512.8	18,281.5	2,464.8	1.1	302.8	15,512.8	.2	.0	.0	.2	.0
Kentucky	12,160.8	655.5	.0	280.1	11,225.2	12,160.8	655.5	.0	280.1	11,225.2	.0	.0	.0	.0	.0
Louisiana	15,074.7	595.7	1.3	144.3	14,333.4	14,558.1	595.7	1.3	144.3	13,816.8	516.6	.0	.0	.0	516.6
Mississippi	16,735.3	1,138.3	.5	169.1	15,427.4	16,715.6	1,138.3	.5	160.4	15,416.4	19.7	.0	.0	8.7	11.0
Oklahoma	17,814.2	291.0	8.0	243.3	17,271.9	8,513.3	224.4	.0	123.8	8,165.1	9,300.9	66.6	8.0	119.5	9,106.8
Tennessee	13,560.9	620.1	.0	441.6	12,499.2	13,160.5	620.1	.0	441.2	12,099.2	400.4	.0	.0	.4	400.0
Texas	114,878.1	781.3	.0	1,338.7	112,758.1	23,279.3	615.1	.0	191.6	22,472.6	91,598.8	166.2	.0	1,147.1	90,285.5
Total	229,920.8	7,186.7	10.9	3,121.0	219,602.2	128,030.2	6,953.9	2.9	1,843.9	119,229.5	101,890.6	232.8	8.0	1,277.1	100,372.7
Total, South	323,163.2	12,481.3	11.1	6,655.9	304,014.9	219,036.0	12,248.5	3.1	5,169.9	201,614.5	104,127.2	232.8	8.0	1,486.0	102,400.4
Rocky Mtn. and Great Plains:															
Rocky Mtn.:															
Arizona	63,662.2	11,465.5	12,596.0	6,888.4	32,712.3	18,493.9	6,437.8	1,868.0	1,741.2	8,446.9	45,168.3	5,027.7	10,728.0	5,147.2	24,265.4
Colorado	50,092.7	13,727.2	8,355.0	905.0	27.105.5	22,271.0	10,350.9	3,322.2	629.5	7,968.4	27,821.7	3,376.3	5,032.8	275.5	19,137.1
Idaho	45,324.7	20,131.8	11,985.0	265.1	12,942.8	21,726.6	16,235.3	465.2	39.0	4,987.1	23,598.1	3,896.5	11,519.8	226.1	7,955.7
Montana	75,893.3	16,744.1	8,142.0	2,432.9	48,574.3	22,559.3	13,817.2	834.0	1,672.2	6,235.9	53,334.0	2,926.9	7,308.0	760.7	42,338.4
Nevada	64,571.0	6,390.4	48,376.0	4,456.5	5,348.1	7,683.3	2,402.9	3,986.8	240.5	1,053.1	56,887.7	3,987.5	44,389.2	4,216.0	4,295.0
New Mexico	66,785.3	8,575.6	12,957.0	3,468.6	41,784.1	18,059.8	7,181.6	2,015.1	693.1	8,170.0	48,725.5	1,394.0	10,941.9	2,775.5	33,614.1
Utah	45,258.4	8,124.2	22,641.1	3,815.1	10,678.0	15,557.4	5,076.9	5,951.2	496.0	4,033.3	29,701.0	3,047.3	16,689.9	3,319.1	6,644.7
Wyoming	56,924.5	9,228.3	17,407.0	2,289.4	27,999.8	10,028.3	5,652.7	723.1	2,124.2	1,528.3	46,896.2	3,575.6	16,683.9	165.2	26,471.5
Total, Rocky Mtn.	468,512.1	94,387.1	142,459.1	24,521.0	207,144.9	136,379.6	67,155.3	19,165.6	7,635.7	42,423.0	332,132.5	27,231.8	123,293.5	16,885.3	164,721.9
Great Plains:															
Kansas	17,622.6	107.9	1.0	185.1	17,328.6	1,344.4	.0	.0	70.8	1,273.6	16,278.2	107.9	1.0	114.3	16,055.0
Nebraska	25,303.5	351.5	4.0	155.5	24,792.2	1,029.1	41.0	.0	17.0	971.1	24,274.4	310.5	4.0	138.5	23,821.4
North Dakota	12,717.7	1,105.6	68.0	335.8	11,208.3	421.8	983.1	3.0	52.5	366.3	12,295.9	1,105.6	65.0	283.3	10,842.0
South Dakota	25,099.7	1,995.2	276.0	403.8	22,424.7	1,702.0	983.1	41.0	33.3	644.6	23,397.7	1,012.1	235.0	370.5	21,780.1
Total, Great Plains	80,743.5	3,560.2	349.0	1,080.2	75,754.1	4,497.3	1,024.1	44.0	173.6	3,255.6	76,246.2	2,536.1	305.0	906.6	72,498.5
Total, Rocky Mtn. and Great Plains	549,255.6	97,947.3	142,808.1	25,601.2	282,899.0	140,876.9	68,179.4	19,209.6	7,809.3	45,678.6	408,378.7	29,767.9	123,598.5	17,791.9	237,220.4
Pacific Coast:															
Pacific Northwest:															
Alaska	350,616.5	19,999.3	285,727.1	31,714.2	13,175.9	119,144.9	12,028.8	89,236.1	10,979.6	6,900.4	231,471.6	7,970.5	196,491.0	20,734.6	6,275.5
Oregon	52,132.7	15,583.0	15,740.1	510.6	20,299.0	29,810.0	13,759.9	4,770.1	167.9	11,112.1	22,322.7	1,823.1	10,970.0	342.7	9,186.9
Washington	31,076.0	9,071.9	307.1	1,762.9	19,934.1	23,181.0	8,424.0	41.6	1,008.7	13,706.7	7,895.0	647.9	265.5	754.2	6,227.4
Total	433,825.2	44,654.2	301,987.7	33,987.7	53,409,0	172,135.9	34,212.7	94,047.8	12,156.2	31,719.2	261,689.3	10,441.5	207,726.5	21,831.5	21,789.8
Pacific Southwest:															
California	83,191.7	20,265.4	15,578.0	8,319.0	39,029.3	40,152.0	15,845.1	906.0	2,067.8	21,333.1	43,039.7	4,420.3	14,672.0	6,251.2	17,696.2
Hawaii	2,954.0	.0	.0	308.0	2,646.0	1,986.0	.0	.0	12.0	1,974.0	968.0	.0	.0	296.0	672.0
Total	86,145.7	20,265.4	15,578.0	8,627.0	41,675.3	42,138.0	15,845.1	906.0	2,079.8	23,307.1	44,007.7	4,420.3	14,672.0	6,547.2	18,368.2
Total, Pacific Coast	519,970.9	64,919.6	317,352.3	42,614.7	95,084.3	214,273.9	50,057.8	94,953.8	14,237.0	55,026.3	305,697.0	14,861.8	222,398.5	28,378.7	40,058.0
Total, United States	1,556,560.7	186,861.9	460,189.4	77,290.9	832,218.5	736,558.4	141,824.6	114,184.4	29,515.5	451,033.9	820,002.3	45,037.3	346,005.0	47,775.4	381,184.6

[1]Less than 0.05 thousand acres.

Source: Forest land - U.S. Department of Agriculture, Forest Service. *Forest Statistics of the U.S. 1977.*

Rangeland - U.S. Department of Agriculture, Forest Service estimates based upon data supplied by U.S. Department of Agriculture, Soil Conservation Service; U.S. Department of Interior, Bureau of Land Management, Bureau of Indian Affairs, National Park Service and U.S. Department of Defense.

Table 2.4 — *Forest land areas in the United States, by timber productivity class and section, region, and State*

(Thousand acres)

Section, region and State	Total	Productivity class[1]						
		120+ cu. ft.	85-120 cu. ft.	50-85 cu. ft.	20-50 cu. ft.	0-20 cu. ft.	Productive deferred	Productive reserved
North:								
Northeast:								
Connecticut	1,860.8	45.5	196.3	618.1	945.7	24.7	0.0	30.5
Delaware	391.8	35.0	82.1	138.6	128.7	5.6	.0	1.8
Maine	17,718.3	2,382.3	5,123.2	5,852.5	3,506.0	633.6	.0	220.7
Maryland	2,653.2	222.2	759.5	1,130.6	410.4	21.6	.0	108.9
Massachusetts	2,952.3	172.8	587.2	862.0	1,175.7	50.1	.0	104.5
New Hampshire	5,013.5	450.5	1,175.9	1,742.5	1,323.1	237.8	25.0	58.7
New Jersey	1,928.4	70.0	41.1	524.1	1,221.6	37.6	.0	34.0
New York	17,218.4	880.3	1,832.0	5,536.3	5,994.7	407.8	.0	2,567.3
Pennsylvania	16,825.9	802.5	3,683.7	7,354.3	4,083.2	370.2	.0	532.0
Rhode Island	404.2	18.6	35.1	119.5	222.1	.0	.0	8.9
Vermont	4,511.7	474.5	862.2	1,603.3	1,489.9	20.3	.0	61.5
West Virginia	11,668.6	1,041.8	3,718.7	4,754.5	1,968.7	24.5	36.0	124.4
Total	83,147.1	6,596.0	18,097.0	30,236.3	22,469.8	1,833.8	61.0	3,853.2
North Central:								
Illinois	3,810.4	400.7	922.3	1,727.2	642.1	65.0	8.2	44.9
Indiana	3,942.9	31.6	151.6	2,381.5	1,250.3	80.4	9.0	38.5
Iowa	1,561.3	40.7	115.1	344.9	959.5	25.2	.0	75.9
Michigan	19,270.4	250.9	1,452.8	6,537.9	10,536.6	205.0	19.0	268.2
Minnesota	16,709.2	166.3	2,044.3	4,998.9	6,485.6	1,835.5	3.0	1,175.6
Missouri	12,876.0	32.3	525.5	2,866.4	8,864.4	298.3	33.0	256.1
Ohio	6,146.6	571.7	1,009.2	2,489.6	1,958.3	9.4	6.0	102.4
Wisconsin	14,907.7	164.7	1,570.3	5,281.7	7,461.3	381.5	14.0	34.2
Total	79,224.5	1,658.9	7,791.1	26,628.1	38.158.1	2,900.3	92.2	1,995.8
Total, North	162,371.6	8,254.9	25,888.1	56,864.4	60,627.9	4,734.1	153.2	5,849.0
South:								
Southeast:								
Florida	17,039.7	136.1	2,321.1	8,973.2	3,899.6	1,594.1	1.1	114.5
Georgia	25,256.0	693.1	5,886.3	16,671.8	1,561.1	30.2	.0	413.5
North Carolina	20,043.3	391.0	3,275.0	12,143.5	3,752.7	46.2	1.1	433.8
South Carolina	12,249.4	292.2	2,106.4	7,288.8	2,488.7	12.6	1.5	59.2
Virginia	16,417.4	149.4	1,700.8	10,762.9	3,325.7	70.0	34.0	374.6
Total	91,005.8	1,661.8	15,289.6	55,840.2	15,027.8	1,753.1	37.7	1,395.6
South Central:								
Alabama	21,361.1	2,747.6	7,947.7	9,175.6	1,462.2	.0	.0	28.0
Arkansas	18,281.5	1,124.3	3,650.0	8,303.4	5,129.0	22.4	13.3	39.1

Kentucky	12,160.8	922.7	3,043.7	4,945.6	2,989.9	46.1	.0	212.8
Louisiana	14,558.1	2,309.1	5,406.4	6,088.4	722.7	.0	13.2	18.3
Mississippi	16,715.6	3,050.4	8,230.2	4,877.8	345.9	.0	.0	211.3
Oklahoma	8,513.3	38.6	230.4	1,879.1	2,175.3	4,157.5	.0	32.4
Tennessee	13,160.5	544.9	2,465.7	6,497.2	3,312.0	.0	18.5	322.2
Texas	23,279.3	1,204.7	4,679.9	5,639.9	988.0	10,733.8	18.1	14.9
Total	128,030.2	11,942.3	35,654.0	47,407.0	17,125.0	14,959.8	63.1	879.0
Total, South	219,036.0	13,604.1	50,943.6	103,247.2	32,152.8	16,712.9	100.8	2,274.6
Rocky Mountain and Great Plains:								
Rocky Mountain:								
Arizona	18,493.9	8.8	164.2	1,186.2	2,536.4	14,196.4	19.1	382.8
Colorado	22,271.0	8.5	356.7	2,608.6	8,340.9	9,520.1	752.2	684.0
Idaho	21,726.6	2,049.8	3,042.5	4,496.0	3,952.3	5,337.7	935.3	1,913.0
Montana	22,559.3	1,376.3	3,586.7	4,394.0	5,002.4	5,489.4	708.7	2,001.8
Nevada	7,683.3	2.9	13.0	29.3	89.1	7,543.1	.0	5.9
New Mexico	18,059.8	50.2	122.6	1,480.3	3,884.4	11,692.3	279.5	550.5
Utah	15,557.4	.0	84.8	437.0	2,882.8	11,842.9	157.3	152.6
Wyoming	10,028.3	.0	143.5	1,430.0	2,760.7	2,674.2	331.3	2,688.6
Total, Rocky Mountain	136,379.6	3,496.5	7,514.0	16,061.4	29.449.0	68,296.1	3,183.4	8,379.2
Great Plains:								
Kansas	1,344.4	.0	.0	542.7	644.3	157.4	.0	.0
Nebraska	1,029.1	.0	.0	63.6	725.2	226.5	.0	13.8
North Dakota	421.8	.0	.0	81.2	323.8	13.6	.0	3.2
South Dakota	1,702.0	.0	5.1	162.8	1,299.2	223.8	.0	11.1
Total, Great Plains	4,497.3	.0	5.1	850.3	2,992.5	621.3	.0	28.1
Total, Rocky Mountain and Great Plains	140,876.9	3,496.5	7,519.1	16,911.7	32,441.5	68,917.4	3,183.4	8,407.3
Pacific Coast:								
Pacific Northwest:								
Alaska	119,144.9	1,447.0	2,673.2	2,819.3	4,210.6	107,482.7[2]	318.8	193.3
Oregon	29,810.0	8,317.0	4,855.0	8,176.0	2,863.0	4,598.0	284.0	717.0
Washington	23,181.0	7,074.0	3,447.0	6,241.0	1,160.0	3,197.0	318.0	1,744.0
Total	172,135.9	16,838.0	10,975.2	17,236.3	8,233.6	115,277.7	920.8	2,654.3
Pacific Southwest:								
California	40,152.0	4,134.0	3,620.0	5,887.0	2,662.0	22,216.0	268.0	1,365.0
Hawaii	1,986.0	948.0	.0	.0	924.0	.0	114.0	
Total	42,138.0	5,082.0	3,620.0	5,887.0	2,662.0	23,140.0	268.0	1,479.0
Total, Pacific Coast	214,273.9	21,920.0	14,595.2	23,123.3	10,895.6	138,417.7	1,188.8	4,133.3
Total, United States	736,558.4	47,275.5	98,946.0	200,146.6	136,117.8	228,782.1	4,626.2	20,664.2

[1]A measure of the mean net annual growth obtainable in cubic feet per acre in fully stocked natural stands.

[2]Includes some 18 million acres that may be classified in higher productivity classes (commercial timberland) upon completion of forest surveys in interior Alaska.

Source: U.S. Department of Agriculture, Forest Service. *Forest Statistics of the U.S., 1977.*

Table 2.5 — *Forest land areas in the United States, by timber productivity class and ecosystem*
(Thousand acres)

Ecosystem	Total	Productivity class[1]						
		120+ cu. ft.	85-120 cu. ft.	50-85 cu. ft.	20-50 cu. ft.	0-20 cu. ft.	Productive deferred	Productive reserved
Forest land:								
Eastern forest:								
White-red-jack pine	12,496.0	1,197.0	2,474.7	4,620.8	3,533.1	143.6	12.1	514.7
Fir-spruce	21,224.0	2,087.9	4,234.5	4,556.7	6,681.4	2,619.3	6.9	1,037.3
Longleaf-slash pine	17,060.0	324.4	3,825.5	10,282.0	2,322.8	201.4	3.7	100.2
Loblolly-shortleaf pine	50,348.5	4,177.8	15,130.4	25,403.4	5,287.3	95.2	34.0	220.4
Oak-pine	35,084.5	2,835.8	9,475.8	17,043.4	5,284.5	202.9	18.1	224.0
Oak-hickory	113,762.2	3,925.9	17,721.9	50,574.4	36,672.9	2,705.5	80.5	2,081.1
Oak-gum-cypress	29,184.7	2,996.4	8,768.5	12,839.7	2,080.9	2,016.6	3.1	479.5
Elm-ash-cottonwood	23,315.1	1,956.6	4,419.5	8,224.6	7,717.0	755.0	.6	241.8
Maple-beech-birch	38,750.8	1,821.4	6,470.5	13,872.4	14,081.7	166.2	76.1	2,262.5
Aspen-birch	20,430.3	349.0	3,734.9	10,019.0	5,139.8	202.2	15.0	970.4
Nonstocked	10,145.0	186.8	575.5	3,389.3	5,869.0	111.8	3.9	8.7
Total	371,801.1	21,859.0	76,831.7	160,825.7	94,670.4	9,219.7	254.0	8,140.6
Western forest:								
Douglas-fir	38,505.2	8,602.8	5,504.9	10,731.5	6,058.0	4,608.1	970.8	2,029.1
Ponderosa pine	33,501.8	1,123.4	3,223.4	8,573.1	13,728.9	4,989.4	472.0	1,391.6
Western white pine	565.9	186.3	149.8	71.8	37.7	82.8	9.5	28.0
Fir-spruce	113,378.1	3,261.3	3,755.5	7,204.6	5,634.3	88,362.0	1,371.6	3,788.8
Hemlock-sitka spruce	19,776.9	5,179.1	3,771.3	3,582.7	332.8	5,999.6	338.7	572.7
Larch	2,815.2	645.4	728.1	871.3	187.1	135.7	52.0	195.6
Lodgepole pine	21,217.6	405.4	2,188.0	4,082.1	6,059.2	3,963.7	895.0	3,624.2
Redwood	786.0	587.0	39.0	36.0	.0	5.0	.0	119.0
Other western softwoods	4,446.3	.1	16.3	114.3	376.6	3,375.9	105.6	457.5
Western hardwoods	39,764.0	3,801.9	1,869.9	2,651.5	6,539.1	24,429.5	157.0	315.1
Nonstocked	6,523.6	1,623.8	868.1	1,402.0	2,493.7	134.0	.0	2.0
Total	281,280.6	25,416.5	22,114.3	39,320.9	41,447.4	136,085.7	4,372.2	12,523.6
Other forest:								
Chaparral-mountain shrub	15,477.0	.0	.0	.0	.0	15,477.0	.0	.0
Pinyon-juniper	47,305.0	.0	.0	.0	.0	47,305.0	.0	.0
Other	20,694.7	.0	.0	.0	.0	20,694.7	.0	.0
Total	83,476.7	.0	.0	.0	.0	83,476.7	.0	.0
Total, forest land	736,558.4	47,275.5	98,946.0	200,146.6	136,117.8	228,782.1	4,626.2	20,664.2

[1] A measure of the mean net annual growth obtainable in cubic feet per acre in fully stocked natural stands.
Source: U.S. Department of Agriculture, Forest Service. Forest Statistics of the U.S., 1977.

Table 2.6 — *Average annual herbage and browse production and area by productivity class of range ecosystem in the contiguous States*

Ecosystem	Ecosystem average	Area	Productivity class[1] 1	2	3	4
	Pounds per acre	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
Grassland:						
Mountain grasslands	1,661	26,871	0	914	20,826	5,131
Mountain meadows	2,824	3,284	0	2,090	1,194	0
Plains grasslands	1,016	175,239	0	1,826	80,595	92,818
Prairie	3,318	41,186	1,985	9,692	29,509	0
Desert grasslands	307	24,744	0	0	0	24,744
Annual grasslands	2,064	10,153	0	1,987	5,992	2,174
Wet grasslands	5,139	4,411	1,318	2,461	0	632
Alpine	564	6,775	0	0	783	5,992
Shrublands:						
Sagebrush	1,027	129,872	0	0	61,847	68,025
Desert shrub	249	81,171	0	0	2,908	78,263
Southwestern shrubsteppe	488	43,213	0	0	790	42,423
Shinnery	1,870	4,726	8	1,689	385	2,644
Texas savanna	2,142	28,429	0	5,502	21,610	1,317
Chaparral-mountain shrub[2]	1,929	15,477	0	4,611	7,253	3,613
Pinyon-juniper[2]	385	47,305	0	0	0	47,305
Desert	0	7,490	0	0	0	7,490
Western forests:						
Douglas-fir	2,262	38,505	0	7,192	23,710	7,603
Ponderosa pine	1,627	33,502	2,533	2,312	4,733	23,904
Western white pine	3,823	566	11	403	147	5
Fir-spruce	1,232	113,378	0	0	71,177	42,201
Hemlock-Sitka spruce	4,189	19,777	3,413	13,829	2,535	0
Larch	2,537	2,815	0	997	1,818	0
Lodgepole pine	1,762	21,218	0	4,988	10,950	5,280
Redwood	4,781	786	385	401	0	0
Hardwoods	1,880	39,764	163	0	27,976	11,625
Eastern forests:						
White-red-jack pine	1,346	12,496	0	0	12,496	0
Spruce-fir	784	21,224	0	0	695	20,529
Longleaf-slash pine	2,096	17,060	0	2,940	14,120	0
Loblolly-shortleaf pine	2,230	50,348	0	5,863	44,485	0
Oak-pine	2,358	35,084	28	5,912	28,331	813
Oak-hickory	1,153	113,762	1,723	8,664	3,420	99,955
Oak-gum-cypress	1,241	29,185	1,300	0	2,813	25,072
Elm-ash-cottonwood	2,619	23,315	0	3,779	19,536	0
Maple-beech-birch	1,476	38,751	0	0	38,751	0
Aspen-birch	1,410	20,430	0	0	20,430	0

[1] Productivity classes: 1 - 5,000 pounds or more per acre per year; 2 - 3,000 to 4,999 pounds; 3 - 1,000 to 2,999 pounds; 4 - less than 1,000 pounds.
[2] Considered as other forest in previous tables.

Use of Forest and Range Lands

Forest and range lands and associated water areas are important sources of basic raw materials for the Nation's economy; at the same time, they play a vital role in the social and cultural life of its people. In addition to supplying materials such as timber, minerals, and forage for domestic livestock, these lands and waters also provide wilderness, a wide range of recreation activities, water, and wildlife and fish. Because of their great extent and basically natural character, they are also important in maintaining a balance in the natural environment.

The uses of forest and range lands are many and variable, and depend in part on the nature, character, and location of these lands. They also depend on the density and character of the population that uses them. Major ones are discussed in a summary manner in the parts of this chapter that deal with each major geographic section and in more detail in succeeding chapters. However, some major points are noted here.

First, uses of forests and rangelands take place in many different combinations depending on the character of the lands, their past treatment, their present ownership and management, and even the time of

year. Practically every acre of forest and range land contributes to more than a single use at one time or another and, in this sense, all forest and range lands are multiple-use lands. For a variety of reasons, certain uses are restricted or prohibited on some lands. But even these lands typically support uses other than the one that is designated the major use. For example, areas designated as wilderness and used primarily for recreation provide wildlife habitat and water, and in some areas, grazing.

Many of the Nation's forests and rangelands are often termed "multiple-use" lands because no specific use is automatically assigned dominance. Most of the 460 million acres administered by the Bureau of Land Management and the 187 million acres of National Forests are called multiple-use lands because no overall use priorities have been established. Many, perhaps most, private forest and range lands are also used and managed for a variety of purposes.

Second, conflicts among uses are often minimal for common combinations and intensities of use and management. That is, the use of an area for one purpose does not usually preclude its use and value for other purposes. As the intensity of management and use increases, however, the potential for competition among uses also increases; careful planning is required to integrate various uses on each area. Overall, the use of forest and range lands can be maximized under management that encourages multiple uses of most areas.

Third, the various uses of forest and range lands must be considered in terms of quality, as well as quantity. This is true for commodity uses, such as timber and forage, and for noncommodity uses such as recreation and wilderness. In the same sense that small trees cannot substitute for large, high-quality trees for some products, high-density campgrounds are not a satisfactory substitute for remote areas, for a primitive camping experience. Although the need for qualitative as well as quantitative judgments is well recognized, data that adequately reflect quality differences in uses of forest and range lands are often not available.

Finally, it is important to understand that the Nation's forest and range lands vary in their multiresource potentials to meet our needs for timber, water, wildlife, forage, recreation, and other goods and services. To relate uses to resource area potentials, it is necessary to consider specific requirements to meet specific product or service needs. For example, water used for irrigation differs in its requirements from water used for drinking, swimming, or fishing. Some bodies of water may serve all of these purposes, others only one.

In view of the large size of the United States and its diversity in climate and physical characteristics, forest and range land resources are described for each of the four major geographic sections used in this Assessment — North, South, Rocky Mountains and Great Plains, and Pacific Coast.

Water Areas

The water area in the United States, including estuaries associated with the contiguous States, is 107 million acres, about 5 percent of the Nation's total area (table 2.1). As with forest and range land, the characteristics of this water area vary greatly as a result of differences in size, type of water body (stream, pond, bay, etc.), and source.

Large lakes and streams account for nearly half of the total water area, 50.9 million acres. This area includes lakes and ponds at least 40 acres in size and streams one-eighth of a mile or more in width. Slightly more than half of the area of large lakes and streams, 27 million acres, is in the humid eastern half of the country. Within the East, the large water areas tend to be geographically concentrated in the northern-most tier of States, where glaciation has formed numerous basins for lakes, and in the southern-most tier of States where part of low-lying land along the coasts and major rivers is covered with water.

Another 12.8 million acres, about a quarter of the total large water area, is in Alaska. Most of the remainder, some 10 milion acres, is in the contiguous Western States. A substantial part of this area is manmade reservoirs and impoundments, constructed to store water for irrigation, electric power generation, and flood control.

Small inland water areas total 8.1 million acres. They include streams of less than one-eighth mile in width and lakes and ponds between 2 and 40 acres in size. The geographic distribution of these small water areas is similar to that for the large water areas, generally for the same reasons — rainfall and landform. Many of these small water areas are manmade, largely the product of Federal and State programs concerned with watershed protection and flood prevention. Associated objectives include improving water supplies and increasing water-based outdoor recreation opportunities.

The 47.6 million acres of other water area include the Great Lakes; bays such as the Chesapeake, Delaware, and San Francisco; sounds such as Long Island and Puget; harbors such as New York; Straits of Juan de Fuca and Georgia; and other coastal waters along the Atlantic, Gulf, and Pacific Coasts except those in

Water areas include ponds, lakes, and reservoirs greater than 2 acres in size and streams greater than 120 feet wide.

Alaska and Hawaii. The Great Lakes of the North Central region account for three-quarters of the other water areas. Most of the rest is located in the Atlantic and Gulf Coast States and in Washington.

In the last few decades, as the result of the construction of dams and other impoundments, both large and small water area categories have been growing. The upward trend is expected to continue, although at a slower rate. The water area is accordingly projected to rise from 107 to 118 million acres by 2030, an increase of 10 percent (table 2.2). Most of this increase is likely to be in the large water area category and result from the construction of reservoirs.

All navigable waters — streams, lakes, reservoirs, bays, etc. — have always been considered as publicly owned. Public access, however, is controlled by the owners of adjoining lands.

No single measure of the productivity of the Nation's waters is meaningful because of the different requirements for different uses. Water that cannot sustain aquatic life might be highly desirable for domestic or industrial use. It is evident, however, that these surface waters are of great importance to the Nation. In addition to the domestic and industrial uses, they provide water for irrigation, navigation, and power generation; habitat for waterfowl; and the necessary medium for the existence of fish and other forms of aquatic life. Much of our outdoor recreation is water-based. The suitability of the Nation's water areas for various uses depends in part on the management and use of the adjoining forest and range lands.

The North

The North geographic section of the United States includes 20 States from the Atlantic seaboard west to Minnesota, Iowa, and Missouri, and south to the Ohio River, including West Virginia and Maryland. The northern portion of this section is characterized by moderately long, relatively severe winters. Precipitation is moderate and ranges from 25 to 45 inches. A short growing season of 100-140 frost-free days imposes severe restrictions on agriculture. Most of this area has low relief with some rolling hills and low mountains in the Northeast. Much of the area has been glaciated; glacial landforms are common.

Soils are well suited for forests. Most soils are acid and strongly leached, and have an upper layer of organic matter. Soils with high water tables are common in many areas.

The mid- and southern portion of this section has cold winters and warm summers. Precipitation is greater in the summer months and ranges from 35-60 inches. Most of the area is rolling or nearly flat, but the Appalachian Mountains have high relief up to 3,000 feet. Much of the area has been glaciated. Soils are generally productive and are well suited for deciduous forests and grassland.

Forest Land

Of the 467.8 million acres in the North, 162.4 million acres are forested (table 2.1). This is the second most densely forested section in the country with 39 percent of its land area in forest. Much of the forested area in this densely populated section of the country is in close proximity to large numbers of people.

Forests are the natural or climax vegetation on nearly all the land in this section. Only scattered areas, mostly in Missouri, are natural grasslands. Thus, much of what is now open land in the North would soon revert to forest without man's intervention. This has already happened in many places. During the early settlement, forests were cleared for crop and pasture land. However, some of this land is poorly suited for these uses. As better land was developed, much of the land originally used for crops and pastures was abandoned and reverted to forests.

The spruce-fir ecosystem covers 21.2 million acres of the North (table 2.7). This forest is a mainstay of the section's woodpulp industry. Spruce studs, white-cedar fencing and siding, maple and birch furniture stock, veneer, and turned products are also products of these forests. The more remote spruce-fir forests are also popular with recreationists. The numerous lakes and streams found in these forests are famous for trout, salmon, and other cold water sport fishing.

The maple-beech-birch ecosystem covers 36.9 million acres of the North section of the country. It contains some of the most valuable hardwood species for wood products in the North including sugar maple, yellow birch, white birch, and basswood, as well as less valuable species such as red maple and beech. Most maple-beech-birch stands have been logged for their most valuable trees. As a result, they often contain more red maple and beech and a higher percentage of rough or rotten trees than would be found in either natural or managed stands.

In addition to providing valuable timber for a wide range of finished products, the maple-beech-birch ecosystem provides other resource values. This ecosystem is primarily responsible for a profusion of fall color; in much of the North, the fall foliage display is a highly valued asset to millions of tourists and residents. Because the maple-beech-birch ecosystem contains a large variety of plant species existing under variable conditions, it also has a great variety of wildlife species.

Beech-birch-maple forests have become established on large areas previously used for crops or pasture. Typical of this forest type, this pole-sized stand needs a commercial thinning to release crop trees.

Elm-ash-cottonwood is another major forest ecosystem in the North. In recent years, the area of this ecosystem has substantially increased from less than 16 million acres in 1962 to 17.8 million in 1978. One reason is that this is often the first ecosystem to establish itself on abandoned crop- and pastureland, particularly on wet fields and pastures. Another reason has been the past high-grading of maple-beech-birch stands, leaving the elm and ash.

Elm-ash-cottonwood is not a highly desirable ecosystem for timber production. Through most of the North, elm, though noted for its superior bending qualities, toughness, and strength, is seldom found in commercial quantities or sizes because of Dutch Elm disease. But ash, particularly white ash, is still much in demand for such products as baseball bats, hockey sticks, tennis rackets, and tool handles. This ecosystem also provides the bright crimson and yellow fall foliage of the low-lying swamps and meadows in the North.

Table 2.7 — *Forest land area in the eastern United States, by ecosystem and section, region, and State, 1977*

(Thousand acres)

Section, region, and State	All eco-systems	Ecosystem											
		White-red-jack pine	Fir-spruce	Longleaf slash	Loblolly-shortleaf	Oak-pine	Oak-hickory	Oak-gum -cypress	Elm-ash-cotton-wood	Maple-beech birch	Aspen-birch	Non-stocked	Other
North:													
Northeast:													
Connecticut	1,860.8	182.2	32.9	.0	29.4	103.6	739.9	.0	439.3	306.2	27.3	.0	.0
Delaware	391.8	.0	.0	.0	99.2	56.6	154.6	81.4	.0	.0	.0	.0	.0
Maine	17,718.3	1,821.8	8,559.5	.0	.0	191.1	247.0	.0	1,739.9	3,598.9	1,418.3	141.8	.0
Maryland	2,653.2	48.8	11.6	.0	542.6	174.5	1,228.7	103.3	332.7	205.1	.0	5.9	.0
Massachusetts	2,952.3	669.3	31.8	.0	65.9	224.3	622.5	.0	848.2	368.4	63.0	58.9	.0
New Hampshire	5,013.5	1,343.6	698.7	.0	29.4	73.3	325.6	.0	789.8	1,440.7	277.2	35.2	.0
New Jersey	1,928.4	11.7	.0	.0	482.4	184.0	783.7	60.3	244.8	100.1	.0	61.4	.0
New York	17,218.4	1,764.2	1,543.3	.0	.0	299.4	1,329.0	.0	3,147.2	6,659.6	1,174.1	1,301.6	.0
Pennsylvania	16,825.9	898.4	83.7	.0	279.8	187.8	7,019.7	9.9	564.0	6,958.4	617.8	206.4	.0
Rhode Island	404.2	28.8	.0	.0	25.2	38.5	177.4	.0	109.5	12.6	6.1	6.1	.0
Vermont	4,511.7	641.9	815.7	.0	.0	85.7	71.3	.0	498.5	2,115.3	245.5	37.8	.0
West Virginia	11,668.6	101.2	66.7	.0	502.5	571.1	6,767.4	.0	816.3	2,701.1	.0	142.3	.0
Total	83,147.1	7,511.9	11,843.9	.0	2,056.4	2,189.9	19,466.8	254.9	9,530.2	24,466.4	3,829.3	1,997.4	.0
North Central:													
Illinois	3,810.4	.0	.0	.0	42.9	12.3	2,276.5	16.6	1,406.7	14.1	8.9	32.4	.0
Indiana	3,942.9	.0	.0	.0	54.1	38.0	2,414.1	53.7	527.8	767.6	8.8	78.8	.0
Iowa	1,561.3	.2	.0	.0	.0	40.4	881.2	.0	445.4	143.9	7.8	42.4	.0
Michigan	19,270.4	1,892.3	3,212.6	.0	.0	.0	2,058.5	.0	1,718.1	5,244.5	4,571.2	573.2	.0
Minnesota	16,709.2	1,107.4	4,542.7	.0	.0	.0	1,005.5	.0	963.8	1,314.5	7,592.1	183.2	.0
Missouri	12,876.0	.0	.0	.0	246.4	596.9	9,930.1	177.8	688.5	310.9	.0	925.4	.0
Ohio	6,146.6	51.9	18.2	.0	196.7	452.2	2,807.2	23.7	1,282.7	1,085.9	62.9	165.2	.0
Wisconsin	14,907.7	1,222.4	1,576.0	.0	.0	.0	2,706.7	.0	1,267.4	3,565.3	4,231.5	338.4	.0
Total	79,224.5	4,274.2	9,349.5	.0	540.1	1,139.8	24,079.8	271.8	8,300.4	12,446.7	16,483.2	2,339.0	.0
Total, North	162,371.6	11,786.1	21,193.4	.0	2,596.5	3,329.7	43,546.6	526.7	17,830.6	36,913.1	20,312.5	4,336.4	.0

See footnote at end of table.

Table 2.7 — *Forest land area in the eastern United States, by ecosystem and section, region, and State, 1977 — continued*

(Thousand acres)

Section, region, and State	All eco-systems	Ecosystem											
		White-red-jack pine	Fir-spruce	Longleaf slash	Loblolly-shortleaf	Oak-pine	Oak-hickory	Oak-gum -cypress	Elm-ash-cotton-wood	Maple-beech birch	Aspen-birch	Non-stocked	Other
South:													
Southeast:													
Florida	17,039.7	.0	.0	6,370.9	1,064.2	1,406.2	999.5	4,752.6	75.7	.0	.0	2,370.6	.0
Georgia	25,256.0	30.5	.0	5,310.1	6,928.0	4,121.3	4,738.3	2,914.2	554.8	.0	.0	658.8	.0
North Carolina	20,043.3	147.0	13.8	532.7	6,100.0	2,495.9	7,440.7	2,179.8	424.8	220.2	.0	488.4	.0
South Carolina	12,249.4	8.5	.0	1,049.2	4,335.3	2,070.1	2,387.6	1,732.0	276.9	.0	.0	389.8	.0
Virginia	16,417.4	152.1	.0	.0	3,276.8	1,930.7	9,955.4	394.3	325.5	130.3	.0	252.3	.0
Total	91,005.8	338.1	13.8	13,262.9	21,704.3	12,024.2	25,521.5	11,972.9	1,657.7	350.5	.0	4,159.9	.0
South Central:													
Alabama	21,361.1	.0	.0	1,485.2	6,388.5	5,024.2	5,839.1	2,419.0	95.9	.0	.0	109.2	.0
Arkansas	18,281.5	.0	.0	.0	3,685.0	3,042.6	8,431.2	2,767.0	274.0	.0	.0	81.7	.0
Kentucky	12,160.8	38.2	.0	.0	955.6	1,068.1	7,634.8	101.6	949.3	1,367.0	.0	46.2	.0
Louisiana	14,558.1	.0	.0	1,000.8	4,046.9	2,204.6	1,669.1	4,802.7	508.8	.0	.0	325.2	.0
Mississippi	16,715.6	.0	.0	1,051.4	4,271.2	3,473.8	4,284.3	3,258.7	221.3	.0	.0	154.9	.0
Oklahoma	8,513.3	.0	.0	.0	860.1	698.0	2,207.5	846.8	124.9	.0	.0	169.0	3,607.0
Tennessee	13,160.5	99.0	16.8	.0	1,299.9	1,641.6	9,252.6	547.2	150.7	120.2	.0	32.5	.0
Texas	23,279.3	.0	.0	259.7	4,540.5	2,576.2	4,455.3	1,942.1	210.3	.0	.0	165.7	9,129.5
Total	128,030.2	137.2	16.8	3,797.1	26,047.7	19,729.1	43,773.9	16,685.1	2,535.2	1,487.2	.0	1,084.4	12,736.5
Total, South	219,036.0	475.3	30.6	17,060.0	47,752.0	31,753.3	69,295.4	28,658.0	4,192.9	1,837.7	.0	5,244.3	12,736.5
Total, East[1]	383,738.7	12,261.4	21,224.0	17,060.0	50,348.5	35,084.5	113,762.2	29,184.7	23,315.1	38,750.8	20,430.3	9,580.7	12,736.5

[1]Includes 81.7 thousand acres of oak-hickory, 186.1 thousand acres of elm-ash-cottonwood, and 117.8 thousand acres of aspen-birch in North Dakota; 64.1 thousand acres of oak-hickory and 199.9 thousand acres of elm-ash-cottonwood in South Dakota; 1.5 thousand acres of oak-pine, 669.7 thousand acres of oak-hickory, and 531.8 thousand acres of elm-ash-cottonwood in Kansas; and 104.7 thousand acres of oak-hickory and 373.8 thousand acres of elm-ash-cottonwood in Nebraska.

Source: U.S. Department of Agriculture, Forest Service. *Forest Statistics of the U.S. 1977.*

The oak-hickory ecosystem covers over 43 million acres, more forest land than any other ecosystem in the region. This ecosystem takes on different characteristics depending on where it is found; in fact, there are eight separate associations under the broad oak-hickory ecosystem — post, blackjack oak, black or bear oak; chestnut oak; white oak-red oak-hickory; white oak; northern red oak; yellow poplar-white oak-northern red oak; sweetgum-yellow poplar; and mixed hardwoods.

The commercial value of the oak-hickory forest is as variable as the ecosystem itself. Associated with many oak-hickory communities is black walnut, the most valuable native tree species in North America. White oak is important to the tight cooperage industry, and has been a perennial favorite for furniture manufacture. Yellow poplar is important for upholstered furniture and container veneers. However, a major deterrent to management of oak-hickory forests has been the lack of adequate markets for less desirable hardwoods, which are a part of most stands.

There are 20.3 million acres of aspen-birch forest land in the North and over 80 percent is found in the North Central region. This ecosystem is usually a pioneer. If ecological succession is not interrupted by fire, logging, or windstorm, it will gradually give way to one of the other ecosystems because aspen, and, to a lesser degree, the birches, are incapable of reproducing in their own shade.

For upland and big game wildlife species, the aspen-birch ecosystem is a particularly valuable plant community. These forests provide a highly desirable source of food and shelter for ruffed grouse, and young seedling-sapling stands are an important source of browse for deer and moose.

The white-red-jack pine ecosystem covers 11.8 million acres in the North. The ecosystem has two distinct subsystems. In the Northeast, it is usually eastern white pine-eastern hemlock; in the North Central region, red and jack pine are more important. If natural succession is permitted to continue, this ecosystem eventually evolves to maple-beech-birch or fir-spruce.

Eastern white pine was a mainstay of the softwood lumber industry in the late 1800's and early 1900's. It is still highly prized for its fine working qualities. Red pine has a coarser texture and is used mostly for rough construction lumber. Jack pine, a relatively small rough tree, is used mainly as a source of softwood puplwood. The white-red-jack pine ecosystem is also significant to wildlife. Whitetailed deer and black bear are the most common larger mammals in this ecosystem and the jack pine subsystem provides habitat for Kirtland's warbler, an endangered species.

The aspen-birch forest type provides prime ruffed grouse habitat.

Trends in area — Across the North as a whole, forest land area increased slightly during the 25 years from 1952 to 1977. However, a decline of about 5 percent is expected over the next 50 years.

The two regions of the North have had different trends in the past and this is expected to continue. In the Northeast, forest land area increased 8 percent during the 1952-1977 period. This increase was attributable almost entirely to the abandonment of marginal crop and pasture land. In the North Central region, forest land area has declined about 6 percent during the past 25 years due almost entirely to land clearing for agriculture. The current trends are expected to continue over the next 50 years, although at a more modest rate.

Ownership — Of the 162.4 million acres of forest land in the North, 92 percent is in non-Federal, mostly private, ownerships (table 2.3). In the northeastern States, the percentage of non-Federal ownership is even higher; 96 percent of the forest land is in private or non-Federal public ownerships.

The non-Federal forest lands in the Northern section of the country are predominantly private lands held by many owners whose individual holdings are small in size. Maine, where half of the private land is owned by forest industries, is an exception to this ownership pattern.

Although non-Federal public forest lands are scattered throughout the States in the North, the largest

concentrations are in New York and Pennsylvania in the Northeast, and in Michigan, Minnesota, and Wisconsin.

Federal forest land in the North accounts for 13.6 million acres, only 8 percent of the total. National Forest lands, which account for 84 percent of all Federal forests in the section, are found in 13 of the 20 States, but are concentrated in the North Central region. The relatively small amount of public forest land in the North emphasizes the importance of private forests in meeting the many forest resource needs of the large urban population.

Productivity — In the North, about 5 percent of the forest land is capable of producing more than 120 cubic feet of wood per acre per year (table 2.4). Another 16 percent is capable of producing 85-120 cubic feet per acre per year and 35 percent could produce 50-85 cubic feet. Of the remainder, most is marginal or submarginal as timber land, capable of producing less than 50 cubic feet per acre per year. About 6 million acres are potentially productive forest lands reserved from timber production.

Generally speaking, the productive capability of forest land is higher in the Northeast region than in the North Central. In the Northeast, 30 percent of the forest land can produce in excess of 85 cubic feet per acre, while only 29 percent of forest area falls in the 0-50 cubic foot category. In the North Central region, only 12 percent of the forest area can produce in excess of 84 cubic feet per acre and the 0-50 cubic foot class accounts for 52 percent of all forest land.

There are several reasons for the poorer forest productivity in the North Central region. Through a large portion of the northern Lake States, wet, boggy lands support slow-growing black spruce, northern white-cedar, and tamarack. Also, extensive areas that were heavily logged and repeatedly burned are covered with aspen and jack pine — two post-fire species that come in under such adverse conditions. In Missouri, where 71 percent of the forest land is in the 0-50 cubic foot class, large areas of shallow hardpan soils support blackjack and post oak forest types.

Rangelands

Rangelands make up only a small portion — 1.8 million acres — of the land area of the 20 States in the North. Most of the rangeland — 1.4 million acres — is in Missouri (table 2.8). Practically all of the remainder is in four States — Maryland, New Jersey, Iowa, and Minnesota.

The wet grasslands and the prairie ecosystems are the only rangeland ecosystems in the North. The wet grasslands in the Northeast region are primarily northern cordgrass prairie communities. Smooth and saltmeadow cordgrasses and seashore saltgrass are dominant grass species. Other important plants include such forbs as seaside gerardia, sea-lavender, seaside plantain, glasswort, and shore podgrass. In the North Central region, the wet grasslands include the tule marshes in low, poorly drained areas. Several species of tules, bulrushes, and cattails are predominant plant species. Sedges are abundant and contribute significantly to the production of herbage.

The prairie ecosystem is the most important rangeland ecosystem in the North Central region. Two communities, the bluestem prairie and the cedar glades, dominate. The bluestem prairie, a rich and productive mixture of grasses and forbs, was once a sea of tall grasses between the eastern deciduous forests and the shorter grasses of the plains grassland ecosystem. Only vestiges remain now, as most of it was converted to high-yielding croplands. Big and little bluestem, switchgrass, and Indian grass are major components of this once-extensive grassland which also includes a large variety of forbs such as leadplant, sunflower, blazing star, and surfpea. The cedar glades, more common in Missouri than the other States in the region, are less productive than the bluestem communities. They have a very rich mixture of grasses, forbs, and small trees: Hackberry, juniper (redcedar), post oak and winged elm are common trees. Grasses provide a good supply of forage for grazing animals. Many of the forbs characteristic of the bluestem prairies are also important plants in the glades. Locally, shrubs such as coralberry and such trees as blackjack oak, chinkapin, and black oak become important members of the community.

Ownership — Private landowners and non-Federal public agencies control 1.5 million acres, or 84 percent, of the rangeland, in the North (table 2.3). Of the 294,000 acres of Federal rangelands, the Forest Service administers 175,000, all in Missouri.

Productivity — The wet grasslands found in several States in the North are the most productive ecosystem of all those identified in this Assessment; production ranges up to 10,000 pounds of herbage per acre per year on the most productive sites. The prairie ecosystem is the second most productive grassland ecosystem, producing more than 3 tons of herbage annually on a per acre basis.

Water Areas

The North has over half of the Nation's water area (table 2.1). Large and small inland lakes and streams are found in every State in this section of the country. About 60 percent of the 13.5 million acres of inland

water is in the North Central region, with largest concentrations in Minnesota, Wisconsin, and Michigan. Maine and New York in the Northeast also have numerous inland water areas.

The northern section also has 42 million acres of other water areas, most of the Nation's total. The largest part of this water area is in the Great Lakes; the remainder is in the coastal estuaries, including Chesapeake and Delaware Bays, Long Island Sound, and New York Harbor.

The inland waters in the North provide habitat for fish and waterfowl. With the heavy concentration of population, particularly in the Northeast, they are used by tens of millions of people for various outdoor recreation activities. They also provide most of the water used for domestic and industrial purposes in the area.

Over half of the forest land in the South is grazed.

The South

The South stretches from Virginia and Kentucky along the South Atlantic and along the Gulf Coast to include Texas and Oklahoma. Much of this 13-State section is characterized by a subtropical climate with mild winters and high humidity, particularly in the coastal plain and Piedmont areas. The Appalachian Mountain area has cool winters and hot summers. In both areas, rainfall is generally ample at all times of the year. In contrast, the plains grasslands ecosystem in west Texas has an arid climate with long, hot summers.

The Coastal Plain has gentle slopes with little local relief. Marshes, lakes, and swamps are common. The Piedmont is gently sloping with local relief between 100 and 600 feet. The southern Appalachian Mountains are steep with much relief up to 3,000 feet, and peaks exceeding 6,000 feet. The western grassland ecosystems are characterized by gently rolling plains.

Soils in the Piedmont and Coastal Plain are usually strongly leached, rich in iron and aluminum oxides, and deficient in many of the plant nutrients essential for successful agricultural production. Loess areas of the Mississippi Valley and flood plains of the major streams have the better soils for crops in the South.

Forest Land

The South contains over 532 million acres of land with forests a dominant part of the landscape. Forests cover 41 percent of this area — 219 million acres (table 2.1).

The importance of forests as vegetative cover varies by region and State within the South. In the five Atlantic seaboard States, 91 million acres, or almost two-thirds of the land area, is forested. In the South Central region, comprising eight Gulf Coast and interior States, only one-third of the land area is forested. In the South Central region, forests reach their western limits in the arid rangelands of western Texas and Oklahoma.

The forest ecosystems of the South include areas that vary from highly productive timberlands to extremely poor sites that are submarginal for investment in timber growing.

Native forage often grows abundantly beneath timber stands, in natural openings, and on cutover lands, providing food for substantial numbers of range livestock.

The South is a major timber-producing region. This is largely attributable to the loblolly-shortleaf pine ecosystem, which occupies almost 48 million acres. Loblolly pine is the keystone of the southern pine forest products industry. Except in Florida, where slash pine prevails, loblolly is the dominant pine species in each of the Atlantic and Gulf Coastal tates south of New Jersey. Nearly half of the total southern pine inventory in the United States is of loblolly.

Although the standing inventory of shortleaf pine is only about half that of loblolly, shorteaf is still far more abundant than longleaf and slash pines combined. The heaviest concentration of shortleaf pine is in the Ouachita Mountains of Arkansas; other short-

leaf areas are in east Texas and in the Piedmont, especially the Carolinas.[4] Throughout much of the loblolly-shortleaf pine ecosystem, the two species often grow in association. But shortleaf pine is also found in commercial quantities well beyond the botanical range of loblolly pine.

Bordering the Atlantic and Gulf Coasts from South Carolina to east Texas is the longleaf-slash pine ecosystem. Altogether, there are over 17 million acres in the ecosystem, of which two-thirds is concentrated in Florida and Georgia. Widespread fire control enabled slash pine to invade sites formerly occupied by longleaf; slash pine has also been extensively planted through the ecosystem.

Nearly 32 million acres or 91 percent of the entire oak-pine ecosystem is found in the South, frequently in residual stands left after cutting of merchantable pine in mixed pine-hardwood forests. Through cultural practices such as cull hardwood removal, some areas have been converted to productive timberlands, and other areas offer similar opportunities. The oak-pine ecosystem, though not as productive as the pine ecosystems for timber production, provides valuable habitat for numerous wildlife species.

The 69 million acres in the oak-hickory ecosystem make up one-third of the total forest land area in the South. This ecosystem is composed of a large number of species in many local associations growing on a wide variety of sites. Some localities within the ecosystem are capable of growing choice industrial hardwoods — examples are the loessial bluffs that flank the eastern edge of the lower Mississippi Valley and the deep coves of the southern Appalachians. The ecosystem also occurs on millions of acres, especially on the Coastal Plain, that are regarded as better adapted to growing pine than hardwoods.[5]

The relatively valuable swamp and bottomland forests that make up the oak-gum-cypress and elm-ash-cottonwood ecosystems total 33 million acres. These ecosystems have long been the mainstay of the southern hardwood forest products industry. In recent years, however, changing land-use patterns have adversely affected them. Extensive acreages of prime bottomland hardwoods have been cleared for agriculture on the alluvial soils of the Mississippi Valley.[6] At the same time, reservoirs in the South have inundated sites capable of producing sweetgum, tupelo, sycamore, and other preferred hardwood species. Though the impoundments are a boon to fishing and other water-based recreation, they usually flood acres that are above average in hardwood-producing capability, and are also prime habitat for many wildlife species.[7]


Areas of bottomland hardwoods, like this site formerly covered with cypress and gum, have been cleared for crop or pasture use, destroying prime timber stands and wildlife habitat for many species.

Other forest ecosystems that occur in the South account for less than 10 percent of the total forest area. Most of this acreage consists of woodlands in central and west Texas and Oklahoma that are largely useful for nontimber goods and services such as grazing, wildlife, and recreation.

Most forests of the South provide good to excellent habitat for wildlife. The hardwood and mixed hardwood-conifer ecosystems, however, provide generally better habitat for a wide variety of wildlife than do the pine forests. Deer and squirrel are important game animals throughout the South. Hunting for quail and turkey attracts people from outside the South, and management of large tracts for these birds is common in the Southeastern region. In addition, parts of the South, especially along the Gulf Coast and lower Mississippi, are important wintering areas for migratory birds.

Recreational opportunities abound in the South's forests. Forested areas of the southern Appalachians in Virginia, Tennessee, and the Carolinas, and the Ouachita and Ozark Mountains of Arkansas, are focal points for many forms of outdoor recreation and draw visitors from many parts of the country. Throughout the South, most forested areas are locally important to nearby populations for camping, hunting, hiking, and other outdoor recreational activities.

[4] Sternitzke, H. S., and T. C. Nelson. The southern pines of the United States. Econ. Bot. 24(2):142-150. 1970.

[5] Sternitzke, H. S. Coastal plain hardwood problem. J. For. 76(3): 152-153. 1978.

[6] Sternitzke, H. S. Impact of changing land use of Delta hardwood forest. J. For. 74(1): 52-57. 1976.

[7] Sternitzke, H. S. Eastern hardwood resources: trends and prospects. For. Prod. J. 24(3):13-16. 1974.

Trends in area — During the past quarter of a century, forest area in the South has increased in some places, declined in others, and changed in composition as the result of shifts in land use. In 1952, forest land totaled over 225 million acres; a decade later, it had increased to almost 231 million acres. Many farmers stopped cultivating land that was eroded, had declined in fertility, or had otherwise proved submarginal as cropland. This change occurred primarily in upland areas, such as the Piedmont. These old abandoned fields provided ideal conditions for natural reseeding, particularly by southern pines; many were also planted. Although some forest land was diverted to other uses, this diversion was overshadowed by the shift from crop- and pasture-land to forest.

Since 1962, the trend has reversed, and forest acreage has declined to a level of 219 million acres. This decline signaled the end of significant additions to forest through crop and pasture land abandonment.

Although reversions of crop and pasture land to forest will continue, the additions are expected to be minor in the future. Furthermore, there appears to be no other major land use change in the offing that would add significantly to forest land. Instead, forests have been cleared to produce soybeans and other crops, first in the Mississippi River alluvial valley and more recently in such areas as the North Carolina coast.[8] Other shifts of land for nonforest uses include conversion to pasture, urban expansion, reservoir construction, and powerlines. This loss had an impact on timber production, as well as some other forest uses. For example, cleared bottomlands represent an important loss of highly productive wildlife habitat. A few States have responded to this decline by purchasing bottomlands for wildlife management areas.

[8] Carter, L. J. Agriculture: a new frontier in coastal North Carolina. Science 189(4199): 272-275. 1975.

Although some abandoned crop and pasture land will revert to forest land in the future, the additions are expected to be much less than the losses.

The more productive forest sites in the Mississippi Valley have been cleared for cropping, and the remaining forest area may not be as desirable for conversion. Thus, though clearing will probably continue, the rate of conversion will likely decline. It is not yet apparent whether the large-scale clearing noted in North Carolina will become more widespread in the Atlantic Coastal Plain. The other major agricultural use for cleared forest land has been pasture. The shift to pasture has been on the upswing in many areas of the South in recent years, and that trend is expected to continue.

Land clearing for crops and pastures is but a part of a larger changing land use pattern. Farmland itself has been lost in recent years due to urban expansion and other causes. As prime crop and pasture land is taken for high-value commercial and residential developments, the need for replacement land will continue to impinge on forests.

Losses of forest land to other uses will also continue. Many metropolitan areas in the South are growing, and rural homesites have also claimed forest land. Powerlines, pipelines, highways, commercial recreational developments, and a host of other uses that are rather permanent in nature will continue to take some forest.

Within the forest land category, the trend of increases in productive-reserved forest is expected to continue as demand for nontimber uses such as recreation grows. As a result, some public forest land available for multiple use will likely be transferred to reserved status. In the private sector, forest industry is expected to increase its holdings as acquisition opportunities become available. Miscellaneous private ownerships have been affected the most by past land use changes, and will continue to lose acreage as forests are claimed for agriculture and other uses in the years ahead.

Ownership — Non-Federal forests in the South total 201.6 million acres, 92 percent of the South's forested area (table 2.3). Non-Federal public forest lands, mostly State lands, are found in every southern State. And private forest lands, about four-fifths of which are in nonindustrial ownerships, constitute a large majority of the forest area in each State.

Both regions in the South — the Southeast and the South Central — have relatively little Federal land. Of the 17.4 million acres of Federal forests, about 71

percent is administered by the Forest Service. These Forest Service lands are found in each of the South's 13 States; the greatest concentration is in Arkansas, with 2.5 million acres. Of the other Federal forest land, 5 million acres are scattered throughout this section — primarily in National Parks and Monuments, and Department of Defense facilities.

Productivity — The South's forest lands have the highest average potential for timber production of any section of the country. Over 76 percent of the 219 million acres of forest are capable of producing 50 cubic feet or more per acre each year (table 2.4).

The South's most productive forest lands, which can produce over 120 cubic feet of wood per acre per year, total 13.6 million acres. Most of this highly productive land is situated in the South Central region. This same region also accounts for over two-thirds of the South's 50.9 million acres capable of producing 85 to 120 cubic feet of wood per year.

Forest lands of moderately productive capacity — 50 to 85 cubic feet — account for almost half of the South's forest land total, and are almost evenly distributed between the South Central and Southeast regions. The same even distribution between regions is true for the 32 million acres in the 20-50 cubic foot class.

In addition, almost 17 million acres of Southern forest land have a productive capacity of less than 20 cubic feet per acre. About three-fourths of the total is in west and central Texas and Oklahoma, mostly in the pinyon-juniper and oak-hickory ecosystems. Most of the remainder is in lowland sites in the Florida Panhandle.

Wet grasslands — a common range type along the coastal areas of the South.

Rangelands

Of the 323.2 million acres of forest and range land in the South, one-third is rangeland, 97 percent of which is in Texas and Oklahoma (table 2.8).

Nine rangeland ecosystems are represented in the South. Scattered along the coastline from Virginia to Texas are the northern and southern cordgrass prairies, both part of the highly productive wet grasslands ecosystem. Plants of the Virginia and Carolina coasts are similar to those of the coastal prairies of the North. On the southern cordgrass prairie, smooth cordgrass, reed, seashore saltgrass, panic grasses, and several species of bulrushes grow up to 8 feet in height. In Florida, which accounts for most of the Southeast's 2.2 million acres of rangeland, the most important communities of the wet grasslands ecosystem are the palmetto prairie, with its wiregrass and saw palmetto, and the Everglades dominated by sawgrass and sweet and red bog.

The South's 13.6 million acres of prairie ecosystem, centered in Oklahoma and Texas, are similar to the prairie ecosystem in Missouri, but have some typically southern species such as Texas needlegrass. In southern Texas, the prairie ecosystem may include groves of oak-hickory forest. Typically, however, the trees are short and branchy and generally considered noncommercial. Further to the West, the 31.5 million acres of shinnery and Texas savanna — mixed grass, shrub and small tree lands — give way to more arid shrub and grassland ecosystems.

The plains grassland ecosystem, the largest ecosystem in the contiguous States, totals 36.2 million acres in the South, dominating western Oklahoma and northern Texas. Once termed "The Great American Desert" because of its lack of trees, the ecosystem provided pastureland for millions of buffalo, elk, and antelope. Though the large herds of wild animals are gone, the medium and short grasses still remain to provide forage for cattle and sheep as well as remnant populations of wild ungulates. The plains grassland is a mosaic of grass species whose distribution is affected by local soil conditions. Blue, hairy, and sideoats gramas, threeawn, and squirreltails are common on well-drained sites.

Ownership — As in the north, the bulk of the rangelands of the South are owned by private individuals or corporations, States, counties, and local municipalities. The Forest Service administers almost a

quarter million acres in Texas and Oklahoma (table 2.5). Other Federal agencies administer 1.5 million acres of rangeland, mostly in Texas, Oklahoma, and Florida.

Productivity — Southern rangelands include both the most and the least productive rangelands in the contiguous States. The southern cordgrass and Everglades communities of the wet grasslands ecosystem average from 2 to 4 tons of herbage and browse production annually. The best sites are capable of producing 5 tons or more. The arid shrub and grass ecosystems of western Texas are among the least productive rangeland, producing only 200 to 400 pounds annually (table 2.6). Between these two extremes are the prairie and Texas savanna ecosystems, which annually average 3,300 and 2,100 pounds, respectively. On the best sites, however, they may produce 5,000 to 6,000 pounds of herbage and browse annually.

Water Areas

Water areas of the South total 23.4 million acres, 4 percent of the section's total area (table 2.1). About 70 percent of both the total water area, and the 16 million acres in large bodies of inland water, are located in five States — Virginia, Florida, North Carolina, Louisiana, and Texas. The large inland water area includes the lower Mississippi and its major tributaries, the large lakes and waterways of the Mississippi Delta, Lake Okeechobee and other lowland lakes in Florida, and the many large water impoundments constructed throughout the South for flood control, power generation, recreation, and water storage. Small ponds and streams total over 3 million acres, and are well distributed throughout the South.

The natural and artificial inland waters, as well as the 3.6 million acres of coastal bays and estuaries, provide valuable habitat for fish and wildlife. While most waters provide such habitat for resident populations of wildlife on a continuing basis, many water areas in the South — such as the Mississippi Delta — also provide crucial habitat for vast populations of overwintering migratory birds. The areas also provide sites for water based recreational activities enjoyed by millions of people each year.

The Rocky Mountains and Great Plains

The Rocky Mountain area stretches from Canada to the Mexican border and includes eight States (Montana, Idaho, Wyoming, Utah, Nevada, Colorado, Arizona, and New Mexico). The neighboring Great Plains area includes four States (North Dakota, South Dakota, Nebraska, and Kansas). Together, these areas contain 740 million acres, about one-third of the entire land area of the United States.

This section of the country has a semiarid continental climate in which evaporation usually exceeds precipitation, despite maximum rainfall during the summer. Winters are cold and dry; summers warm to hot. Winter precipitation is greater in mountainous areas than in the plains area.

This vast section of the country exhibits many landforms. The rolling plains of the Plains States and eastern extremes of the Rocky Mountain States give way to the steep, glaciated terrain of the Rocky Mountains. The Rocky Mountain States are also characterized by high elevation plateaus and interior basins, and the highly eroded tablelands of Utah and Arizona. In southern and western portions of this section — Arizona, New Mexico, Utah, and Nevada — there are extensive desert areas.

The dominant soil-forming process is calcification, with salinization on the poorly drained soils. Soils often contain an excess of precipitated calcium carbonate and are very rich in bases. Organic matter content is low except for forested areas and the tall grass prairies. Moisture is generally the most limiting factor for plant growth.

The Rocky Mountains have a wide range of land forms and vegetation.

Table 2.8—*Rangeland area in the contiguous States by ecosystem and section, region, and State, 1976*

(Thousand acres)

Section, region, and State	Total rangeland and other forest land	Grasslands								
		Total grass-lands	Mountain grass-lands	Mountain meadow	Plains grass-lands	Prairie	Desert grass-lands	Annual grass-lands	Wet grass-lands	Alpine
North:										
Northeast:										
Connecticut	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delaware	([1])	([1])	.0	.0	.0	.0	.0	.0	([1])	.0
Maine	.4	.4	.0	.0	.0	.0	.0	.0	.4	.0
Maryland	83.7	83.7	.0	.0	.0	.0	.0	.0	83.7	.0
Massachusetts	.1	.1	.0	.0	.0	.0	.0	.0	.1	.0
New Hampshire	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
New Jersey	60.5	60.5	.0	.0	.0	.0	.0	.0	60.5	.0
New York	1.8	1.8	.0	.0	.0	.0	.0	.0	1.8	.0
Pennsylvania	.1	.1	.0	.0	.0	.0	.0	.0	.1	.0
Rhode Island	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Vermont	.2	.2	.0	.0	.0	.0	.0	.0	.2	.0
West Virginia	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total	146.8	146.8	.0	.0	.0	.0	.0	.0	146.8	.0
North Central:										
Illinois	.3	.3	.0	.0	.0	.0	.0	.0	.3	.0
Indiana	3.1	3.1	.0	.0	.0	.0	.0	.0	3.1	.0
Iowa	38.4	38.4	.0	.0	.0	38.4	.0	.0	.0	.0
Michigan	.4	.4	.0	.0	.0	.0	.0	.0	.4	.0
Minnesota	155.8	155.8	.0	.0	.0	155.8	.0	.0	.0	.0
Missouri	1,447.6	1,447.6	.0	.0	.0	1,447.6	.0	.0	.0	.0
Ohio	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Wisconsin	7.0	7.0	.0	.0	.0	6.3	.0	.0	.7	.0
Total	1,652.6	1,652.6	.0	.0	.0	1,648.1	.0	.0	4.5	.0
Total, North	1,799.4	1,799.4	.0	.0	.0	1,648.1	.0	.0	151.3	.0
South:										
Southeast:										
Florida	2,189.1	2,189.1	.0	.0	.0	.0	.0	.0	2,189.1	.0
Georgia	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
North Carolina	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
South Carolina	20.0	20.0	.0	.0	.0	.0	.0	.0	20.0	.0
Virginia	27.5	27.5	.0	.0	.0	7.5	.0	.0	20.0	.0
Total	2,236.6	2,236.6	.0	.0	.0	7.5	.0	.0	2,229.1	.0
South Central:										
Alabama	54.0	54.0	.0	.0	.0	52.8	.0	.0	1.2	.0
Arkansas	.2	.2	.0	.0	.0	.0	.0	.0	.2	.0
Kentucky	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Louisiana	516.6	516.6	.0	.0	.0	20.0	.0	.0	496.6	.0
Mississippi	19.7	19.7	.0	.0	.0	.0	.0	.0	19.7	.0
Oklahoma	9,300.9	8,696.1	.0	.0	4,877.9	3,818.2	.0	.0	.0	.0
Tennessee	400.4	400.4	.0	.0	.0	400.0	.0	.0	.4	.0
Texas	91,598.8	44,350.4	.0	.0	31,376.1	9,292.2	2,749.9	.0	932.2	.0
Total	101,890.6	54,037.4	.0	.0	36,254.0	13,583.2	2,749.9	.0	1,450.3	.0
Total, South	104,127.2	56,274.0	.0	.0	36,254.0	13,590.7	2,749.9	.0	3,679.4	.0
Rocky Mountain and Great Plains:										
Rocky Mountain:										
Arizona	58,823.6	10,354.7	425.2	52.5	.0	.0	9,877.0	.0	.0	.0
Colorado	35,227.4	19,421.1	1,365.2	413.6	15,270.0	1,723.4	53.8	.0	15.7	579.4
Idaho	24,182.4	1,797.6	654.5	506.1	.0	.0	.0	.0	12.1	624.9
Montana	54,155.6	49,299.5	11,765.4	196.9	36,994.4	.0	.0	.0	1.9	340.9
Nevada	62,735.7	635.5	309.9	244.7	.0	.0	.0	.0	80.9	.0
New Mexico	59,831.8	25,789.0	766.1	20.5	14,097.7	.0	10,881.2	.0	20.6	2.9
Utah	39,614.7	2,469.5	386.6	74.8	.0	.0	1,181.8	.0	328.4	497.9
Wyoming	47,607.9	23,830.1	1,201.7	347.5	20,667.3	.0	.0	.0	15.6	1,598.0
Total, Rocky Mountain	382,179.1	133,597.0	16,874.6	1,856.6	87,029.4	1,723.4	21,993.8	.0	475.2	3,644.0

[1]Less than 0.05 thousand acres.

Table 2.8—*Rangeland area in the contiguous States by ecosystem and section, region, and State, 1976* — continued

(Thousand acres)

Section, region, and State	Total shrub-lands	Shrublands						Other forest land		
		Sage-brush	Desert shrub	South-western shrub-steppe	Shinnery	Texas savanna	Desert	Total	Chaparral-mountain shrub	Pinyon-juniper
North:										
Northeast:										
Connecticut	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delaware	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Maine	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Maryland	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Massachusetts	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
New Hampshire	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
New Jersey	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
New York	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Pennsylvania	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Rhode Island	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Vermont	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
West Virginia	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
North Central:										
Illinois	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Indiana	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Iowa	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Michigan	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Minnesota	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Missouri	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Ohio	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Wisconsin	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total, North	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
South:										
Southeast:										
Florida	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Georgia	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
North Carolina	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
South Carolina	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Virginia	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Total	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
South Central:										
Alabama	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Arkansas	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Kentucky	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Louisiana	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Mississippi	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Oklahoma	604.8	.0	.0	.0	604.8	.0	.0	.0	.0	.0
Tennessee	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Texas	47,248.4	.0	26.7	16,301.6	2,491.3	28,428.8	.0	.0	.0	.0
Total	47,853.2	.0	26.7	16,301.6	3,096.1	28,428.8	.0	.0	.0	.0
Rocky Mountain and Great Plains:										
Rocky Mountain:										
Arizona	34,813.6	4,668.1	22,504.4	7,640.5	.0	.0	.6	13,655.3	1,629.0	12,026.3
Colorado	8,400.6	7,668.8	731.8	.0	.0	.0	.0	7,405.7	2,998.7	4,407.0
Idaho	21,800.5	20,396.1	886.6	.0	.0	.0	517.8	584.3	180.0	404.3
Montana	4,034.5	4,034.5	.0	.0	.0	.0	.0	821.6	345.4	476.2
Nevada	56,252.2	34,673.1	19,462.4	.0	.0	.0	2,116.7	5,848.0	1,188.8	4,659.2
New Mexico	22,936.5	1,689.3	326.6	19,270.9	1,629.7	.0	20.0	11,106.3	427.6	10,678.7
Utah	27,231.5	10,411.8	12,092.5	.0	.0	.0	4,727.2	9,913.7	955.5	8,958.2
Wyoming	23,066.1	20,981.5	2,084.6	.0	.0	.0	.0	711.7	134.0	577.7
Total, Rocky Mountain	198,535.5	104,523.2	58,088.9	26,911.4	1,629.7	.0	7,382.3	50,046.6	7,859.0	42,187.6

[1]Less than 0.05 thousand acres.

Table 2.8—*Rangeland area in the contiguous States by ecosystem and section, region, and State, 1976*—continued

(Thousand acres)

Section, region, and State	Total rangeland and other forest land	Grasslands								
		Total grass-lands	Mountain grass-lands	Mountain meadow	Plains grass-lands	Prairie	Desert grass-lands	Annual grass-lands	Wet grass-lands	Alpine
Great Plains:										
Kansas	16,278.2	16,278.2	.0	.0	8,196.1	8,082.1	.0	.0	.0	.0
Nebraska	24,274.4	24,272.0	.0	.0	9,746.9	14,525.1	.0	.0	.0	.0
North Dakota	12,295.9	12,295.9	.0	.0	12,089.8	206.1	.0	.0	.0	.0
South Dakota	23,402.1	23,396.8	63.6	.0	21,922.4	1,410.8	.0	.0	.0	.0
Total, Great Plains	76,250.6	76,242.9	63.6	.0	51,955.2	24,224.1	.0	.0	.0	.0
Total, Rocky Mountain and Great Plains	458,429.7	209,839.9	16,938.2	1,856.6	138,984.6	25,947.5	21,993.8	.0	475.2	3,644.0
Pacific Coast:										
Pacific Northwest:										
Oregon	24,803.7	3,861.4	2,958.3	123.5	.0	.0	.0	.0	.0	779.6
Washington	7,895.0	3,813.2	2,780.2	73.6	.0	.0	.0	.0	2.2	957.2
Total	32,698.7	7,674.6	5,738.5	197.1	.0	.0	.0	.0	2.2	1,736.8
Pacific Southwest:										
California	53,289.7	17,074.6	4,194.2	1,230.2	.0	.0	.0	10,153.5	102.9	1,393.8
Total	53,289.7	17,074.6	4,194.2	1,230.2	.0	.0	.0	10,153.5	102.9	1,393.8
Total, Pacific Coast	85,988.4	24,749.2	9,932.7	1,427.3	.0	.0	.0	10,153.5	105.1	3,130.6
Total, contiguous States	650,344.7	292,662.5	26,870.9	3,283.9	175,238.6	41,186.3	24,743.7	10,153.5	4,411.0	6,774.6

'Less than 0.05 thousand acres

Forest Land

Nearly 141 million acres, 19 percent of the total land area of the Rocky Mountain and Great Plains section, is forested (table 2.1). Forests of the Rocky Mountain States total over 136 million acres, and are predominantly softwood species (table 2.9). The most heavily forested States, and the land areas occupied by forest, are: Idaho, 41 percent; Colorado, 34 percent; Utah, 30 percent; Arizona, 23 percent; Montana, 24 percent and New Mexico, 23 percent (fig. 2.3). Three States — Montana, Idaho, and Colorado — have nearly half the total forest land in the Rocky Mountains. Forests of the Plains States, which total only 4.5 million acres, are largely of hardwood species.

Two eastern hardwood ecosystems are found in the Plains States: elm-ash-cottonwood in major river bottoms, and oak-hickory, an upland forest type. The five largest forest ecosystems in the Rocky Mountains, totaling some 111 million acres, are pinyon-juniper, ponderosa pine, Douglas-fir, fir-spruce, and lodgepole pine. Together these ecosystems account for roughly 80 percent of the forest area in this section of the country. All except pinyon-juniper are important producers of wood products.

The pinyon-juniper ecosystem occupies over 42 million acres, principally in the arid regions of Arizona, New Mexico, western Colorado, Utah, and Nevada. In Arizona and New Mexico, it is the predominant forest ecosystem. This rather uniform type with few tree species occupies an elevation zone below ponderosa pine and above the desert shrubs. The species composition, however, changes geographically and can vary from pure pinyon to pure juniper.

The ponderosa pine ecosystem is found in all the Rocky Mountain and Plains States except Kansas and North Dakota. It occupies some 18 million acres, nearly half of which is in Arizona and New Mexico. Found primarily in the arid transition zone, it is the first forest ecosystem of importance for wood production encountered above the desert floor, and also the most important in this section of the country in terms of timber output. Ponderosa pine often consists of pure stands, especially in Arizona, New Mexico, and the Black Hills of South Dakota. In Idaho and Montana, ponderosa is often associated with Douglas-fir, larch, and other species requiring more moisture.

The Douglas-fir ecosystem in this section occupies the area immediately above the ponderosa pine zone and below the fir-spruce ecosystem. Over 12 million of the total 17.5 million acres of this ecosystem are in

Table 2.8—*Rangeland area in the contiguous States by ecosystem and section, region, and State, 1976* — continued

(Thousand acres)

Section, region, and State	Total shrub-lands	Shrublands						Other forest land		
		Sage-brush	Desert shrub	South-western shrub-steppe	Shinnery	Texas savanna	Desert	Total	Chaparral-mountain shrub	Pinyon-juniper
Great Plains:										
Kansas	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Nebraska	2.4	2.4	.0	.0	.0	.0	.0	.0	.0	.0
North Dakota	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
South Dakota	.9	.9	.0	.0	.0	.0	.0	4.4	.0	4.4
Total, Great Plains	3.3	3.3	.0	.0	.0	.0	.0	4.4	.0	4.4
Total, Rocky Mountain and Great Plains	198,538.8	104,526.5	58,088.9	26,911.4	1,629.7	.0	7,382.3	50,051.0	7,859.0	42,192.0
Pacific Coast:										
Pacific Northwest:										
Oregon	18,461.3	14,994.6	3,466.7	.0	.0	.0	.0	2,481.0	64.0	2,417.0
Washington	4,081.8	4,081.8	.0	.0	.0	.0	.0	.0	.0	.0
Total	22,543.1	19,076.4	3,466.7	.0	.0	.0	.0	2,481.0	64.0	2,417.0
Pacific Southwest:										
California	25,965.1	6,269.1	19,588.5	.0	.0	.0	107.5	10,250.0	7,554.0	2,696.0
Total	25,965.1	6,269.1	19,588.5	.0	.0	.0	107.5	10,250.0	7,554.0	2,696.0
Total, Pacific Coast	48,508.2	25,345.5	23,055.2	.0	.0	.0	107.5	12,731.0	7,618.0	5,113.0
Total, contiguous States	294,900.2	129,872.0	81,170.8	43,213.0	4,725.8	28,428.8	7,489.8	62,782.0	15,477.0	47,305.0

[1]Less than 0.05 thousand acres.

Idaho and Montana. Pure stands of Douglas-fir are found in southeast Idaho, northern Colorado, Wyoming, and Utah, wherever it has developed as a climax forest. In Montana and northern Idaho, grand fir, Engelmann spruce, and western larch are common associates and frequently are the dominant species. In terms of timber output, this ecosystem is second only to ponderosa pine in this section of the country.

The lodgepole pine ecosystem typically consists of pure, or nearly pure, very dense stands of the namesake species. This ecosystem totals nearly 17 million acres, about 60 percent of which is in Idaho and Montana; most of the rest is in western Wyoming and central Colorado. Lodgepole pine stands are frequently replaced through succession by such other conifers as Douglas-fir, grand fir, and subalpine fir. In many cases, however, pure stands of lodgepole pine may take on the appearance of a climax type. Dense stands in this ecosystem usually have no understory flora.

Of the fir-spruce ecosystem, nearly all 16 million acres are found in Idaho, Montana, Wyoming, Colorado, and Utah. The system occupies high elevation areas where temperatures are cool and moisture abundant. Grand fir, subalpine fir, and Engelmann spruce are major species. Some of the more common associates in the northern Rocky Mountains are larch, western redcedar, and western white pine. In Colorado, Wyoming, and Utah, this ecosystem occurs up to timberline.

The western white pine, larch, and hemlock ecosystems are found exclusively in Idaho and Montana and comprise less than 4 percent of the total forest land in the section. The western white pine ecosystem occupies roughly the same temperature belt as the Douglas-fir ecosystem — moist sites above the ponderosa pine and below the fir-spruce. In this subclimax type, there is generally a mixture of western redcedar, western hemlock, grand fir, Douglas-fir and western larch, with ponderosa pine at lower elevations and Engelmann spruce at higher elevations.

The larch ecosystem occurs west of the Continental Divide in Montana and generally north of the Salmon River in Idaho. Western larch, a deciduous conifer, is a subclimax species often maintained by fire. In some areas of North Idaho, it is a pioneer species. On cooler and moister sites, associated species are Douglas-fir and grand fir; on drier sites, ponderosa pine is found.

The hemlock ecosystem has both western and mountain hemlock as major species. Mountain hem-

lock is found at higher elevations up to timberline in association with whitebark pine, subalpine fir, and Engelmann spruce. Western hemlock is a major component of the ecosystem at elevations up to 6,000 feet. Where western redcedar is a major associate, the ecosystem may represent a climax forest; where existing areas of the ecosystem have followed fires, less shade-tolerant species such as white pine and Douglas-fir are still retained. About 85 percent of this ecosystem is in Idaho.

The 1.3 million acres of the elm-ash-cottonwood ecosystem are found along major river drainages in the Plains States: the Red River in North Dakota, the Big Sioux and James Rivers in eastern South Dakota, the Platte and Republican Rivers in Nebraska, and the Kansas River and its tributaries in north-central Kansas. The oak-hickory ecosystem is found in all the Plains States, but the most extensive area is in east and southeast Kansas. North Dakota has a small area of aspen-birch along the Canadian border. The aspen-birch ecosystem is also found in scattered areas throughout the Rocky Mountains.

The forest ecosystems of the Rocky Mountain States are valued for a number of uses. While an important segment of the Nation's softwood timber industry depends on these forests, some forests are also components of valuable wilderness areas. This section's forests provide dispersed recreation opportunities for millions of people, habitat for big game animals including elk and mule deer, and are among the most valuable watersheds in the Nation. Because much of the region is sparsely settled and relatively inaccessible for logging, only in recent years have conflicts among alternative forest land uses become a matter of widespread concern. However, increased accessibility and the growing demand for outdoor recreation, wilderness protection, and timber have made the forests of this section highly prized by a wide range of interests.

Trends in area— Historical trends in forest area in the Rocky Mountains and Great Plains section are difficult to evaluate because of lack of early historical data. Some forest land was cleared of trees for early settlement and, in many cases, forests were exploited for railroad ties, mine timbers, and charcoaling for ore reduction. Most areas cleared for these latter uses have reverted back to forest.

During the past 10 years, total forest land area in the section has declined by 600,000 acres. The bulk of this loss occurred in the southwest in the pinyon-juniper ecosystem, where large areas have been cleared for livestock range.

Future prospects are for forest land acreage to remain relatively stable. Although some decline in area can be expected from water development projects and conversion to range, these reductions should be minor.

Even though the total area of forest land is not expected to change significantly in the future, allocation of forest land for various uses may change. In the Rocky Mountain States, 3 million acres of roadless areas on the National Forests are being evaluated for suitability for inclusion in the Wilderness System. The forest land associated with those areas selected will not be used to produce timber, although most other resource uses and values would be maintained and available in varying degrees.

Ownership— About 68 percent of the forest land in the Rocky Mountains and Great Plains section is administered by Federal agencies. In the Plains States, 72 percent of the forests are in private and State or county ownership (table 2.3). Most Federal land in this region is in the Black Hills National Forest in South Dakota.

In the Rocky Mountain States, Federally owned or administered forest land totals 94 million acres, two-thirds of the forest area. No State has less than 51 percent of the forest land in Federal ownership; and Idaho has 77 percent, Utah, 74 percent, Montana, 72 percent, and Nevada 86 percent.

The Forest Service administers the majority of Federal forest lands in every Rocky Mountain State except Nevada and Utah, where the Bureau of Land Management has the major holdings. For the section as a whole, the Forest Service manages over 67 million acres of forest, almost half of all forest lands.

Non-Federal, mostly private, forest lands are found in every State in the section, but constitute the majority of forest land only in three Plains States— Kansas, Nebraska, and North Dakota. Most of the small amount of forest land owned by forest industries is in Idaho and Montana; most of that held by nonindustrial private owners is in Idaho, Montana, Colorado, and New Mexico.

Productivity— Based on the capacity of the land to produce wood fiber, the productivity of the forest land in the Rocky Mountains and Great Plains section is low. About half the forest land cannot produce 20 cubic feet of wood per acre per year, the standard below which forest land is generally considered unproductive (table 2.4). Less than 20 percent has the capacity to produce 50 or more cubic feet per acre per year. The most highly productive land is found in northern Idaho and in Montana west of the Continental Divide. In these two States, some 19 million acres are capable of producing in excess of 50 cubic feet per acre per year.

Table 2.9—*Forest land area in the western United States, by ecosystem and section, region, and State, 1977*

(Thousand acres)

Section, region, and State	All eco-systems	Ecosystem													
		Douglas-fir	Ponderosa pine	Western white pine	Fir-spruce	Hemlock-sitka spruce	Larch	Lodgepole pine	Redwood	Other western softwoods	Western hardwoods	Non-stocked	Chaparral	Pinyon-juniper	Other
Rocky Mtn. and Great Plains:															
Rocky Mtn:															
Arizona	18,493.9	223.7	4,083.9	0.0	168.6	0.0	0.0	0.0	0.0	5.9	235.3	121.2	1,629.0	12,026.3	0.0
Colorado	22,271.0	1,430.2	1,997.3	.0	4,346.8	.0	.0	2,222.8	.0	75.6	3,198.3	1,217.9	2,998.7	4,407.0	376.4
Idaho	21,726.6	6,858.4	2,032.7	288.6	4,612.8	1,166.2	808.0	3,709.1	.0	606.5	557.6	502.4	180.0	404.3	.0
Montana	22,559.3	5,639.2	2,614.8	56.6	2,631.9	239.5	1,277.2	6,414.0	.0	1,804.7	538.8	226.9	345.4	476.2	294.1
Nevada	7,683.3	20.0	69.1	.7	156.3	2.4	.0	54.4	.0	1,273.9	250.7	7.3	1,188.8	4,659.2	.5
New Mexico	18,059.8	1,279.4	4,230.9	.0	741.6	.0	.0	.0	.0	56.4	440.6	204.6	427.6	10,678.7	.0
Utah	15,557.4	821.0	505.5	.0	1,495.2	.0	.0	737.3	.0	49.8	1,969.8	65.1	955.5	8,958.2	.0
Wyoming	10,028.3	1,176.3	965.0	.0	2,289.3	.0	.0	3,616.8	.0	569.7	460.8	202.5	134.0	577.7	36.2
Total, Rocky Mtn.	136,379.6	17,448.2	16,499.2	345.9	16,442.5	1,408.1	2,085.2	16,754.4	.0	4,442.5	7,651.9	2,547.9	7,859.0	42,187.6	707.2
Great Plains:															
Kansas[1]	1,344.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	141.4	.0	.0	.0
Nebraska[2]	1,029.1	.0	168.9	.0	.0	.0	.0	.0	.0	.0	.0	381.7	.0	.0	.0
North Dakota[3]	421.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	36.2	.0	.0	.0
South Dakota[4]	1,702.0	.0	1,306.3	.0	25.0	.0	.0	.0	.0	3.8	85.1	13.4	.0	4.4	.0
Total, Great Plains	4,497.3	.0	1,475.2	.0	25.0	.0	.0	.0	.0	3.8	85.1	572.7	.0	4.4	.0
Total, Rocky Mtn. and Great Plains	140,876.9	17,448.2	17,974.4	345.9	16,467.5	1,408.1	2,085.2	16,754.4	.0	4,446.3	7,737.0	3,120.6	7,859.0	42,192.0	707.2
Pacific Coast:															
Pacific Northwest:															
Alaska	119,144.9	.0	.0	.0	83,393.6	12,664.8	.0	280.2	.0	.0	22,721.0	85.3	.0	.0	.0
Oregon	29,810.0	10,117.0	5,625.0	52.0	3,763.0	1,134.0	137.0	2,223.0	12.0	.0	2,454.0	1,298.0	64.0	2,417.0	514.0
Washington	23,181.0	7,699.0	2,339.0	60.0	4,078.0	4,418.0	593.0	914.0	.0	.0	2,244.0	802.0	.0	.0	34.0
Total	172,135.9	17,816.0	7,964.0	112.0	91,234.6	18,216.8	730.0	3,417.2	12.0	.0	27,419.0	2,185.3	64.0	2,417.0	548.0
Pacific Southwest:															
California	40,152.0	3,241.0	7,798.0	108.0	5,676.0	152.0	.0	1,046.0	774.0	.0	4,210.0	1,118.0	7,554.0	2,696.0	5,779.0
Hawaii	1,986.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	398.0	664.0	.0	.0	924.0
Total	42,138.0	3,241.0	7,798.0	108.0	5,676.0	152.0	.0	1,046.0	774.0	.0	4,608.0	1,782.0	7,554.0	2,696.0	6,703.0
Total, Pacific Coast	214,273.9	21,057.0	15,762.0	220.0	96,910.6	18,368.8	730.0	4,463.2	786.0	.0	32,027.0	3,967.3	7,618.0	5,113.0	7,251.0
Total, West[5]	355,150.8	38,505.2	33,736.4	565.9	113,378.1	19,776.9	2,815.2	21,217.6	786.0	4,446.3	39,764.0	7,087.9	15,477.0	47,305.0	7,958.2

[1] Kansas State total includes 1.5 thousand acres of oak-pine, 669.7 thousand acres of oak-hickory, and 531.8 thousand acres of elm-ash-cottonwood.
[2] Nebraska State total includes 104.7 thousand acres of oak-hickory and 373.8 thousand acres of elm-ash-cottonwood.
[3] North Dakota State total includes 81.7 thousand acres of oak-hickory, 186.1 thousand acres of elm-ash-cottonwood, and 117.8 thousand acres of aspen-birch.
[4] South Dakota State total includes 64.1 thousand acres of oak-hickory and 199.9 thousand acres of elm-ash-cottonwood.
[5] Ecosystem totals will not add to State totals, for explanation, see footnotes 1, 2, 3, and 4 above.
Source: U.S. Department of Agriculture, Forest Service. *Forest Statistics of the U.S., 1977.*

There is some variation in productivity among ecosystems, due to the site requirements of the species and the soil-moisture-temperature relationships characteristic of the sites on which the ecosystems occur. The ecosystems occupying the most highly productive land are Douglas-fir, ponderosa pine, and fir-spruce.

At the other end of the scale are pinyon-juniper and chaparral-mountain shrub; because of the very nature of these systems and the climatic conditions under which they exist, they cannot produce even 20 cubic feet of wood per acre per year. However, the combined 50 million acres of these two types is valuable for other resource uses.

In addition, some 11.5 million acres of forest land that is capable of producing 20 cubic feet or more per acre annually is in either a reserved category where timber cannot be harvested, or in a deferred category under study for possible use as wilderness.

The Great Plains area is dominated by grasses.

Rangelands

About half of the rangelands in the United States is in the Rocky Mountains and Great Plains. The rangelands, along with the pinyon-juniper and chaparral-mountain shrub forest ecosystems (which are often included with the rangeland ecosystems), occupy some 458 million acres or 62 percent of the land area of this section (table 2.8). The Rocky Mountains and the Great Plains areas differ greatly in physical and climatic characteristics and corresponding differences in rangeland ecosystems.

The Great Plains area with its hot, dry summers and cold, windswept winters is dominated by grasses — short, medium, and tall. Interspersed within these grasslands are stringers of deciduous forest along the tributaries of the Missouri and Mississippi Rivers. Coniferous forests cover isolated mountain uplifts such as the Black Hills in South Dakota and the Bear Paws in Montana. About 26 million acres of the eastern part of the Plains are covered with tall grasses of the prairie ecosystem, including big, little, and sand bluestems; switchgrass; and Indian grass with a rich assortment of forbs. To the west, the prairie ecosystem gives way to the short and medium grasses of the vast plains grassland, which totals 139 million acres, and is the largest in the United States. The bluestems, switchgrass, and Indian grass are replaced by thickspike and western wheatgrass, green needlegrass, needle-and-thread, blue grama, and buffalo grass. The grasslands also include a large and colorful variety of forbs mostly from the aster, snapdragon, pea, and wild buckwheat families.

West of the Great Plains is the Rocky Mountain region, a land of contrasts in temperatures, physiographic relief, and vegetation. Rangelands of this area are usually divided into three general kinds —the foothill and mountain grasslands, the lush mountain meadows and alpine grasslands of the Rockies proper, and the arid and semiarid shrublands and grasslands of the deserts, interior basins, and isolated mountain ranges of the Southwest.

The mountain grasslands, totaling almost 17 million acres, are found in all of the Rocky Mountain States. Montana accounts for over two-thirds of the acreage. Bluebunch wheatgrass, needle-and-thread, rough and Idaho fescues, June grass, and oatgrass are the important grasses in the foothills and mountain grasslands of the northern Rockies. In the central and southern Rockies, rough and Idaho fescues are replaced by Thurbers and Arizona fescue. Forbs make up a large part of the herbaceous vegetation in this ecosystem. Penstemons, larkspurs, lupines, phloxes, vetches, forget-me-not, and brown-eyed susan are colorful components of these ecosystems.

Mountain meadows and alpine grasslands cap the highest ridges and the flanks of the tallest peaks throughout the Rockies. Bent grasses, tufted hairgrass, sedges of many species, mountain timothy and bluegrasses, many forbs, and patches of dwarf willows provide a close and tight ground cover throughout the alpine area in spite of the short growing season and severe climate common to the area.

Sagebrush is the second largest rangeland ecosystem in the United States. Over 104 million acres, or 80 percent of this ecosystem, is in the Rocky Mountain area. It is the major vegetation of the Snake River plains of Idaho, the Bighorn and Wyoming Basins in Wyoming, the basins and isolated mountain

ranges of Nevada and Utah, and the Colorado Plateaus of Arizona. Associated with the many species of sagebrush are wheatgrasses, fescues, bluegrasses and bromes, and broadleaved forbs, all well adapted to the harsh climatic conditions of the area.

Generally south of the sagebrush ecosystem (but interspersed with it in Nevada) lie some 50 million acres of two forest ecosystems often grouped with range — pinyon-juniper and chaparral-mountain shrub. The pinyon-juniper ecosystem, the so-called pygmy forest of the Southwest, is characterized by juniper and pinyon pine growing as open to dense woodlands or savannas. Understory vegetation of wheatgrasses, Indian ricegrass, gramas, and shrubs such as mountain mahogany, sagebrush, and rabbitbrush, depends to a large extent upon the density of the crown canopy. Intermingled with and below the pinyon-juniper lies the main portion of the chaparral ecosystem. Dense-to-open stands of deciduous and evergreen low trees and shrubs occupy the lower flanks of the mountains in Nevada, Utah, and Arizona. Principal trees are alligator and one-seeded junipers and several evergreen oaks. Shrubs such as manzanita, cliff-rose, ceanothus, Apache plume, and silktassel, sometimes form stands so dense that herbaceous vegetation is absent. The acreage in this ecosystem has been reduced in the southwest through clearing to increase forage yields.

Below the pinyon-juniper and the chaparral on even more arid sites, are 80 million acres of the desert shrub and desert grassland ecosystems. Desert shrubs vary from a few inches to several feet tall, and are generally in open stands interspersed among areas of bare soil and rock pavement. Mesquite and acacia are low-growing trees present in the ecosystem. Blackbrush, creosote bush, palo verde, jojoba, prickly pear, cholla, and other cactuses form open to very dense shrub stands. Herbaceous species are mostly absent except in the years of high winter and spring moisture. In such years, forbs that have been unseen for many years will form bright carpets of color.

The dry desert grassland ecosystems occur on tablelands in Arizona, New Mexico, and Utah. Vegetation is predominantly grass with blue grama, galleta, and tabosa being the most common. Shrubs are few and forbs generally not prominent except in the occasional years of abundant rainfall.

The rangelands of the Rocky Mountains and Great Plains support the Nation's range cattle and sheep industries. Cow-calf operations based here provide many of the beef cattle that eventually pass through feedlots on their way to packing plants and to the Nation's tables. These rangelands also support wild horses and burros, antelope, deer, and bighorn sheep, and provide winter range for elk.

The role of the rangelands in the Rocky Mountains and Great Plains in providing outdoor recreation opportunities varies because of the great variation in the lands themselves. Mountain meadows and alpine areas are used for primitive and wilderness camping. Off-road vehicle excursions are common over desert and semi-desert areas.

Established wilderness areas in the Rocky Mountains include some rangelands, especially the mountain meadows in the Rocky Mountain States. However, there are few untouched remnants of the rangelands in the Great Plains, and little has been done to protect examples of desert rangeland types. Desert rangelands are likely to receive consideration in the near future as the Bureau of Land Management prepares an inventory of potential wilderness areas on lands it administers.

Ownership — About 58 percent of the rangeland area in the Rocky Mountains and Great Plains is in non-Federal ownership (table 2.3). In the Great Plains States, 95 percent of the rangeland is in non-Federal ownership; but 50 percent is Federally owned in the Rocky Mountain States. The Forest Service administers 7 percent of the rangeland in the section; the Bureau of Land Management, 30 percent; and the other Federal agencies, only 4 percent. In Nevada, the Federal agencies administer 92 percent of all rangelands.

Productivity — Productivity of the rangeland ecosystems in the Rocky Mountains and Great Plains is highly variable. The grassland and prairie ecosystems of the Great Plains produce on the average 1,000 to 3,000 pounds of herbage and browse per year (table 2.6). On the better sites, they will yield as much as 7,000 pounds per acre. In the rest of the section, only the mountain meadows average better than a ton of herbage and browse per acre. Except for sagebrush and chaparral-mountain shrub, the arid and semiarid ecosystems of the Southwest produce only small amounts of herbage and browse, averaging well below a half ton. The sagebrush and chaparral ecosystems will average from 1,000 to 2,000 pounds per acre, with as much as 3,000 pounds on the best sites.

Water Areas

The Rocky Mountains and Great Plains section is the driest in the country in terms of rainfall. And it has the smallest water area — in absolute as well as relative terms — of all of the sections. The total water acreage — all inland water — is 9.3 million acres, slightly more than 1 percent of the total area (table 2.1). The largest concentrations of water are in Utah, Montana, North and South Dakota.

The water areas of the Dakotas and Montana include the upper Missouri river system with its large water impoundments, and many water storage reservoirs. Utah has 20 percent of this section's water, concentrated mostly in the Great Salt Lake.

In addition to the major river systems flowing from the Rocky Mountains — the Missouri and Snake in the Northern Rockies, and the Colorado — this mountainous area has many small lakes and streams. Arizona, Utah, and Nevada have minimal amounts of these small waters.

Although the inland water areas in the Rocky Mountains and Great Plains are relatively small, they are of great importance. They support fish and wildlife and are the focal points for many outdoor recreational activities. They also provide most of the water for domestic use and for the irrigation of much of the cropland and improved pasture in the more arid parts of the section.

The Pacific Coast

This section includes five States: California, Oregon, Washington, Alaska, and Hawaii. The range of environmental conditions within the region is extreme.

The coastal areas of Southeast Alaska, Washington, Oregon, and Northern California are characterized by a maritime climate with ample precipitation and small ranges in annual temperature. Precipitation ranges from 30-150 inches or more and is well distributed throughout the year. Temperatures are cool and produce a very damp, humid climate with much cloud cover. This area has many steep, rugged mountains fronted in places by narrow coastal plains. The interior mountains rise to 8,000 feet or more. Much of the area has been glaciated, particularly in the northern portion. Soils are strongly leached and acid and have thick surface organic layers. They are highly productive for coniferous forests.

In contrast, the eastern portions of Oregon and Washington, and northeastern California are similar to the more semi-arid Rocky Mountain region. This area is a relatively dry upland with occasional mountain uplifts, and is dissected by the Columbia River and its major tributaries. Soils are very productive where water is available.

Most of California is dominated by a Mediterranean climate with distinct wet and dry seasons. Precipitation falls mainly in the winter months and summers are hot and dry. Physiography ranges from the flat central valley to the steep, low mountains on the coast and the high, rugged Sierra Nevada in the interior. Soils are extremely variable.

The northern and western coastal plains of Alaska are dominated by an arctic climate with short cool summers and long, extremely severe winters. Precipitation is light, often less than 10 inches. Broad, level plains and low, rolling foothills occupy the area. The tundra soil sare wet and cold, and underlain by sand, gravel, and marine sediments. Most soils have a thick permafrost layer.

Interior Alaska is characterized by a subarctic climate and the steep, rugged Brooks and Alaska Mountain ranges. Broad valleys, dissected uplands, and lowland basins occur between the mountain ranges. Soils are strongly leached and have severe climatic limitations. Permafrost is common.

The islands of Hawaii have a tropical climate and are hilly and mountainous. The islands have a complex pattern of leached soils, rocky highlands, and coastlines.

Forest Land

Forests cover 93 million acres, or 46 percent, of the land in the lower Pacific Coast States — California, Oregon, and Washington (table 2.1). The forests in these States are known throughout the world for their large trees. Less well known, but of great importance to resource managers, is the extreme variability in productivity and composition of the forest.

The lower Pacific Coast States' forest ecosystems fall into two forest subregions — the humid coastal area, and the arid eastern or interior area.

The coastal subregion — western Washington and Oregon, and northwestern California — has three major forest types, redwood, Douglas-fir, and hemlock-sitka spruce. The forests in this subregion of heavy rainfall and mild winters are among the most productive in the world. Biomass accumulations in the redwood and Douglas-fir ecosystems exceed those reported for any other ecosystem.[9]

The redwood ecosystem of the California Coast totals only about 800,000 acres, but is important as a timber producing region, scenic wonder, and recreational resource far out of proportion to its limited acreage (table 2.9). Douglas-fir is the major conifer associate throughout the ecosystem, although western hemlock, grand fir, and western redcedar are locally important. Tanoak and Pacific madrone are common hardwood associates throughout most of this ecosystem.

The Douglas-fir ecosystem, which totals 21 million acres, is the largest and most important in terms of

[9] Franklin, J. F., and C. T. Dryness. Natural vegetation of Oregon and Washington. U.S. Department of Agriculture, For. Serv. Gen. Tech. Rep. PNW-8. 1973.

A forest of giant redwoods — an important timber and recreational resource in the Coastal regions of northern California.

timber production of all forest ecosystems in the coastal subregion. It dominates most of the forested area in Washington and Oregon west of the Cascade Range crest, except for the most humid coastal sites. In northern California, it is found generally east of the redwood forests in the coast ranges.

Although Douglas-fir is often found in almost pure stands, common associates include western hemlock and western redcedar. To the south, this ecosystem includes tanoak, live oaks, and pacific madrone. Red alder, tanoak, and hemlock often succeed this shade intolerant species following disturbance.

The hemlock-Sitka spruce ecosystem is found on the Washington and Oregon coasts; it totals almost 6 million acres in these two States, and is limited to moist sites, mostly on the coastal side of the coast range and Washington's Olympic Peninsula. The namesake species of this ecosystem have long been of secondary value to Douglas-fir, but, in recent years, they have found increased use in this country for lumber as well as pulp and as log exports.

The predominant use of these three forest ecosystems has been for timber production. In 1970, softwood sawtimber output from these forests accounted for about one-third of the Nation's total, from only 6 percent of the Nation's timberlands. The forests also support a rich variety of wildlife; and the streams in the region are used by most of the anadromous salmonids in the contiguous United States.

As in other parts of the country, recreational use of these forest ecosystems is important and has been increasing. At higher elevations, especially in the Cascades, the forest floor is relatively open and suitable for hiking and backpacking. Heavy winter snow accumulations above 4,000 feet have made the forests of the Cascades attractive for winter sports.

The interior subregion of Oregon, Washington, and California has forest ecosystems suited to the hot, dry summers and cold winters of this area. The forests of much of the area are similar in composition to Rocky Mountain forests, but they are generally more productive. The largest specimens of ponderosa

pine, lodgepole pine, and Engelmann spruce are found here.[10]

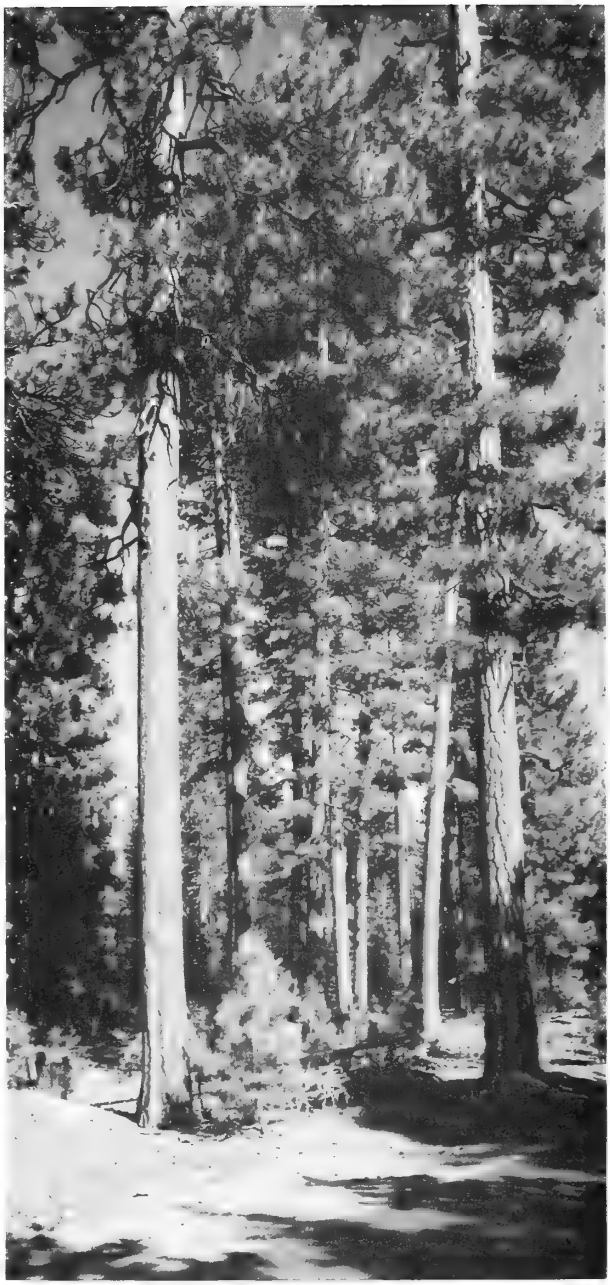
Nine forest ecosystems are found mostly in the interior portions of Oregon, Washington, and California. Of these, the largest and perhaps most important for several uses is the ponderosa pine ecosystem, which totals almost 16 million acres. About half of this area is in California, where ponderosa pine is found in the interior coast ranges and on the lower west slopes and east side of the Sierra Nevada. In Oregon and Washington, ponderosa pine is found on the easternmost slopes of the Cascades and at lower elevations in the mountains east of the Cascades. Stand composition varies from pure stands to stands with numerous associates; depending upon location, these associates include western larch, Douglas-fir, sugarpine, true firs, lodgepole pine and incense-cedar. Ponderosa pine forests are favored for camping, hunting, and hiking, due largely to the open parklike nature of mature stands. They also are important to the livestock industry for grazing, and have supported the important western pine lumber industry for over a century.

The fir-spruce ecosystem in these three States totals 13.5 million acres. It is found at medium to high elevations in most mountain ranges from southern California to the Canadian border. The fir-spruce forests of California are dominated by white fir and California and shasta red firs; in Oregon and Washington, Pacific silver fir, noble fir, alpine fir, grand fir, and Engelmann spruce are the primary species. The fir forests were for decades of little importance for timber, but were valued as part of the scenic beauty of the high mountains. As the more accessible pine forests have been harvested, the fir forests have been increasingly utilized for timber, and in many areas are now approaching the pine forests in terms of total output.

The lodgepole pine ecosystem totals 4.2 million acres, and is found at high elevations in California's Sierra Nevada, and in many mountain locations from the Cascades east in Oregon and Washington.

Western larch and western white pine are two conifer ecosystems whose occurrence and acreage are limited in these States.

The western hardwood ecosystem is well represented in each State, and totals 9 million acres. In California and southern Oregon, California black oak, tanoak, live oaks, and Pacific madrone are major species; further north, red alder and bigleaf maple are the primary species. This ecosystem is often found on disturbed sites that formerly were dominated by conifers. Often found intermingled with conifer forests, the hardwood ecosystem is highly valued for wildlife habitat. The three other ecosystems found in these States—chaparral, pinyon-juniper, and miscellaneous woodlands—total 19 million acres (table 2.9).



Ponderosa pine—a characteristic forest in the Sierra Nevada mountains and on the eastern slopes of the Cascades.

[10] American Forests 72(5), 1966, and 73, Nov. 9, 1976.

The 7.6 million acre area of chaparral stands — dense evergreen, woody shrubs — is almost entirely in California; it is the predominant form of forest cover in the mountains in southern California, and is found in coast ranges and the Sierra Nevada to the north. Most of the 6.3 million acres of miscellaneous woodlands is also found in California, where it is the lowest elevation forest community in the foothills of the coast range and Sierra Nevada surrounding the Great Central Valley. Several species of oaks and Digger pine are most common in this ecosystem. The pinyon-juniper forests are found in eastern Oregon and in California, generally east of the Sierra Nevada and in the mountains of southern California.

These three ecosystems, due to type and yield of vegetation, have very limited value for production of wood products. But they are important as wildlife habitat, and beneficial for watershed protection. To stockmen, these forests are a nuisance. Because grazing is their predominant use, the main treatment has been designed to get rid of the cover by burning or mechanical means. The hardwoods, long used for home fires, are now being considered as a possible source of energy on a larger scale.

The forests of Alaska total 119 million acres, 56 percent of the total forest area of the Pacific Coast region (table 2.1). In productivity and timber volumes, the Alaska forests are much less important than those to the south. Only in southeast Alaska are there substantial areas of productive forest land accessible for timber harvesting. The 12.7 million acres of hemlock-Sitka spruce — the dominant coastal ecosystem — are found from sea level to an elevation of 2,000 feet on the islands and along the fiords of the Alexander Archipelago and southeast Alaska.

The interior forests of Alaska are an extension of the Canadian taiga and aspen-birch forests. The 83.4 million acres of the fir-spruce ecosystem and 22.7 million acres of hardwood forest are in some places locally important for timber processing. However, most of these forests are far from markets, inaccessible, and some 80 percent are not capable of growing more than 20 cubic feet per acre annually. The more productive forests are limited to the major interior river valleys.

Both the interior forests and those of southeast Alaska include vast untrammeled areas that support wildlife in wilderness or near-wilderness settings. Many of the streams contain spawning areas that support the major salmon fishery of North America. Some of these forests, which are intermingled with spectacular mountains, are being considered by Congress for inclusion in the National Park System and the National Wildlife Refuge System. In addition, a number of major areas are being reviewed for wilderness designation.

Trends in area — Forest areas have decreased significantly in parts of the Pacific Coast section since 1952. The decline in forest areas in the lower Pacific Coast States since 1952 totals over 3 million acres, and includes 1.2 million acres capable of producing more than 20 cubic feet of wood per acre per year and 1.8 million acres of lesser capability. For the 1.2 million acres in the higher productivity group, the greatest causes of loss were road building and grazing clearings in Oregon, and urban expansion in the Puget Sound area in Washington.

In California, clearing for grazing and reservoir construction were the leading causes of forest land losses. Almost all of the decline in forest land area for the lower productivity groups occurred in California, where about 1.7 million acres of oak and chaparral have been converted to rangeland since 1952[11] and 100,000 acres have been converted to roads, reservoirs, and other clearings. The decline in California more than offsets an increase in areas of these lands in Oregon and Washington. Juniper woodland has expanded markedly on calcareous soils in eastern Oregon. This is a result of overgrazing in the early 1900's followed by fire control, which favored juniper over the bunchgrass and sagebrush. Foothill and mountain meadows have steadily closed in due to encroachment of trees and brush. Fire control and changing water tables are thought to be the primary causes.

In recent years, the rate of conversion of timberlands and brushlands to farm and open grazing lands has decreased rapidly in California, due in large part to limitations on the use of fire for conversions. It is anticipated that these and other limitations will serve to slow the rate of such conversions in the future.

Road, reservoir, and powerline development, as well as urbanization in some areas, will likely continue to make inroads into the acreage of forests on the Pacific Coast.

Ownership — Almost three-fourths of the 214 million acres of forest land on the Pacific Coast are administered by agencies of the Federal government (table 2.3). In Alaska, 94 percent of the forest area is currently under Federal administration; but selection of State lands and native claims from public domain lands will change the distribution considerably. Currently, the Bureau of Land Management administers 80 percent of the Federal forests in Alaska, the Forest Service, 11 percent.

[11] State of California Division of Forestry. Brushland Range Improvement. (Annual report). 1954-1974.

Of all forest lands, Federal ownership represents 63 percent in Oregon, 41 percent in Washington, and 47 percent in California. In Washington and California, National Forests account for almost all of the Federal forests. In Oregon, however, the Bureau of Land Management manages 25 percent of the Federal forests, and the Forest Service, most of the remainder. There are no Federal forest lands in Hawaii. The non-Federal lands are largely privately owned in Oregon, Washington, and California, but in Hawaii, State ownership is important.

Of over 26 million acres of private forest in the Pacific Coast States that can produce in excess of 20 cubic feet of wood annually, 47 percent is owned and managed by forest industries. Industry ownership has increased in recent years through purchase of other nonindustrial, private lands; forest area in the nonindustrial-private category has been decreasing due to industrial acquistion and conversions to other uses.

Productivity — Two-thirds of the forest acres of the Pacific Coast are in the lowest productivity class; they do not have the capability to produce 20 cubic feet of wood per year. Over three-fourths of these low productivity forests are found in Alaska's harsh interior. Most of the remainder is in the chaparral forest and wooded lowlands of California, and the pinyon-juniper forests in Oregon, Washington, and California.

This section also has 38 million acres of forests capable of producing from 50 to 120 cubic feet of wood, and almost 11 million acres in the class of 20 to 50 cubic feet. In addition, about 4 million acres, or 2 percent, of the forests are capable of producing in excess of 20 cubic feet, but are reserved from timber production due to inclusion in parks and wilderness areas. The acreage in this latter category is likely to increase somewhat in the future.

The productivity of the Pacific Coast forests is as variable for other outputs or uses as it is for timber. Recreation, wildlife habitat, water yield, and forage yield all vary with ecosystem; sites less productive for timber can be highly productive in terms of other uses.

Rangelands

Over one-third of the Nation's rangelands are in the Pacific Coast section. Altogether, the rangelands (including pinyon-juniper and chaparral-mountain shrub) occupy 318.4 million acres, about 56 percent of the five-State area (tables 2.1, 2.8). Almost three-fourths of the rangeland is in Alaska. Minor amounts are in Hawaii.

The rangeland ecosystems can be broken into three groups, those in California, Oregon and Washington; those in Alaska; and those in Hawaii.

The rangeland ecosystems of California, Oregon, and Washington are similar to those of the Rocky Mountains region. The grasslands ecosystems in these three States total about 25 million acres. The mountain grasslands of some 10 million acres are found in abundance in all three States (table 2.8). The mountain meadow and alpine grassland ecosystems are found at high elevations in each State, accounting for over 4.5 million acres in total. The wet grassland ecosystem is found in limited areas in California. The central valleys of California were once occupied by highly productive tule marshes of that ecosystem, but most of those marshes have been converted to cropland and are no longer part of the rangeland base.

The annual grasslands of California — totaling 10 million acres — are unique in that the vegetation is dominated by annual grasses, most of which are not native to the United States. Dominant plants are wild oats, bromes, wild barley, and species of fescue. Forbs are of secondary importance, except during years of abundant rainfall when the California poppy forms a blazing orange blanket over much of the rangelands. Filaree, a member of the geranium family, is probably the most important forb in the annual grasslands. This ecosystem is found in uncultivated areas of California's Great Central Valley, and in the low foothills surrounding it.

Oregon and California have a combined total of over 44 million acres of shrub ecosystems and 12.7 million acres of the two forest ecosystems often included with range — chaparral and pinyon-juniper. Most of the 23 million acres of desert shrub is found in the desert interior of southern California; about 3.5 million acres are located in southeastern Oregon. The sagebrush ecosystem in this section totals 25 million acres, 15 million acres of which are in arid lands of eastern Oregon. In California, the sagebrush ecosystem is mostly in the northeastern corner of the State.

The Alaska rangelands total over 231 million acres. The Alaskan tundra ecosystems are dominated by low shrubs, grasses, sedges, and forbs. Cottongrass is the most widespread of all vegetative types in the tundra ecosystems. In the wet sites, cottongrass and other sedges form a dense mat, but in moist sites, it forms a continuous well-developed cover of tussocks. In the drier sites, cottongrass and sedges give way to

low shrubs such as cranberries, dwarf willows, bog rosemary, and Labrador tea. In the Aleutian tundras, the tall bluejoint reedgrass and low heath shrubs are dominant. Shrub thickets are composed of dense to open stands of alder, devilsclub, salmonberry, willow, and blueberries. Vegetation of the muskeg-bog, with its high water tables, is characterized by sphagnum moss, sedges, rushes, lichens, and low shrubs.

The Hawaiian rangelands, which total almost 1 million acres, are a mixture of trees including koa, guava, and sandalwood; shrubs (cactus and mesquite), and grasses (tanglehead and hairgrasses).

Productivity — Productivity of the rangelands in the three lower Pacific Coast States ranges from about 5,100 pounds per acre in the wet grasslands to about 250 pounds in some of the communities of the desert shrub ecosystem (table 2.6). The annual grasslands are surprisingly productive, averaging better than 2,000 pounds per acre. On the better sites, the annual grasslands can be expected to average 3,000 pounds or more. This type has consistently shown marked and profitable response to fertilization.

The Alaskan ecosystems have generally low productivity levels. Only the shrub thickets and the Aleutian moist tundra with the tall bluejoint reedgrass produce over a ton of herbage and browse per acre on their best sites. In Hawaii, the grass-shrub-barren mosaic is the highest, averaging almost 4,200 pounds per acre and capable of producing up to 9,000 pounds on the best sites.

Ownership — Rangelands in the three States of California, Oregon, and Washington are about equally split between the Federal Government and non-Federal owners (table 2.3). In Washington, which has the smallest area of rangelands of the three States, over three-quarters is in non-Federal ownership. In Oregon and California, on the other hand, only 41 percent is in non-Federal ownership. Over 64 percent of the Federal rangeland in these three States is administered by the Bureau of Land Management.

Of the 231 million acres of rangeland in Alaska, 225 million acres, or 97 percent, is in Federal ownership. The Bureau of Land Management administers the great bulk of the Federal rangelands in the State, 196 million acres, or 87 percent. The Forest Service administers only 8 million acres and the other Federal agencies some 21 million acres. A large part of the rangeland in Hawaii is in State ownership. These lands are often leased to private ranchers for grazing of domestic livestock.

Water Areas

Water areas of the Pacific Coast total 18.1 million acres, about 3 percent of this section's total area (table 2.1). Alaska, with its many large inland lakes and streams, has over 70 percent of the total water area in the Pacific Coast States. Oregon, Washington, and California have a number of large rivers including the Columbia and Sacramento rivers and their tributaries. These States also have many large lakes — both artificial and natural — and many small lakes and streams. The islands of Hawaii have only 19,000 acres of water area, less than 0.5 percent of their total area. Washington, in addition to its inland waters, has 1.5 million acres of coastal water area in the Puget Sound and the Straits of Juan de Fuca.

The rivers and streams of Alaska and the lower Pacific Coast States are vital to the important salmon industry of the Pacific Coast, and provide habitat for other fishes, waterfowl, and other wildlife. Many of these rivers are also used for water sources and power generation.

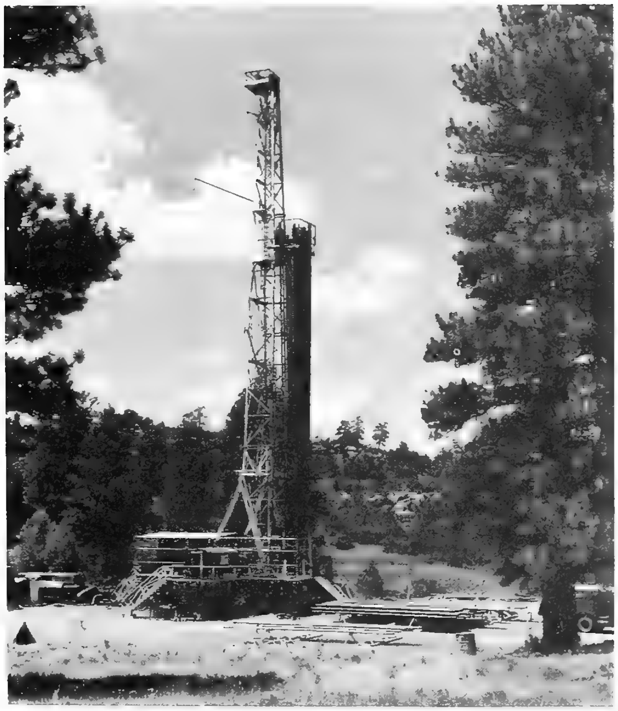
Other Uses and Resources

In addition to the forest and range land resources described above for each of the major sections of the country, four other resources deserve discussion here: minerals, urban forests, wetlands, and air. All are relevant to an assessment of forest and range lands.

Minerals

Mining of most minerals in the United States takes place on forest and range lands. In part, this is because forest and range lands are the most extensive category of lands in the country, but these lands also happen to coincide with major areas of mineralization. For example, the coal mines of Appalachia, the iron and copper mines of the Lake States, and the lead mines of Missouri all fall in heavily forested areas. Most of the oil and natural gas in Texas, Wyoming, and New Mexico, the coal in Montana and Wyoming, and the oil shale in Colorado underlies major rangeland zones.

Although minerals are not renewable products of forest and range lands, they are very important resources; their production has major effects on surface resources and is affected by the production and use of those resources. The greatest impacts occur from surface mining, but the surface effect of underground



Over half of the Nation's reserves of coal and nuclear materials, nearly all the oil shale deposits, and many of the prime petroleum prospecting sites are located on Federal forest and range lands in the western United States.

mining (facilities, waste dumps, land subsidence, and road or rail access) can also be substantial. Where reclamation does not take place, the effects of mining can be long lasting.

The list of minerals that occur beneath forest and range lands in the United States is very long. In terms of their impact on surface uses, three categories of minerals should be recognized: fuels (oil and gas, coal, uranium, and geothermal resources); metals (iron, aluminum, copper and lead); and non-metals (barite, phosphate, potash, sand, gravel, clay, rock and gypsum).

Location — Of present and prospective commercial mineral sources of fuel — coal, shale, crude oil, natural gas, uranium, and geothermal — coal is the most abundant and widespread. Coal underlies about 13 percent of the Nation and is found in 37 States. Since much of it can be mined only by surface methods, coal mining has the potential for serious impacts on other forest and range resources. On the other hand, oil, natural gas, and geothermal resources are associated with relatively low-level impacts on other resources. Oil shale mining could become important in terms of effects on renewable resources; however, at present, problems in extraction have limited its use.

National Forest System lands and Bureau of Land Management lands contain many of the Nation's energy-related minerals. These include about 50 percent of the coal reserves, 60 percent of the nuclear minerals, nearly all of the oil shale deposits, and large quantities of materials such as vermiculite and perlite, important in the manufacture of insulating materials used in the conservation of energy (fig. 2.4).

Most metallic minerals occur in localized areas, primarily in the western United States. Many of these metallic minerals underlie lands managed by the Forest Service and the Bureau of Land Management (fig. 2.5). Probably half of the Nation's copper, lead, zinc, nickel, and molybdenum are contained in these lands, concentrated mostly in the Northern Rocky Mountain and Pacific regions. The lead belt in Missouri, which ranks first nationally in lead production, falls largely on National Forest lands. Only copper, aluminum, iron, and titanium are mined mostly by surface methods, although such other significant metals as uranium and thorium are mined in a variety of ways depending on local situations.

Nonmetallic minerals also generally occur in localized areas, except for construction materials such as sand, gravel, clay, rock, and gypsum. There are vast phosphate deposits in the Rocky Mountain region, and large phosphate and potash deposits in the South.

Construction materials are found both on Federal and non-Federal lands, but only a small proportion is produced on Federal lands. Usually these materials can be obtained at lowest costs from areas close to where they are needed. Unlike most metals and other nonmetallics, the low unit-value construction materials are most often mined from open pits and quarries. They account for a large portion of the surface area disturbed by mining activities, but this portion is widely dispersed for the most part.

Trends in production — The constant dollar value of United States mineral production has grown from $11 billion in 1950 to $33.1 billion in 1975, a threefold increase (table 2.10).

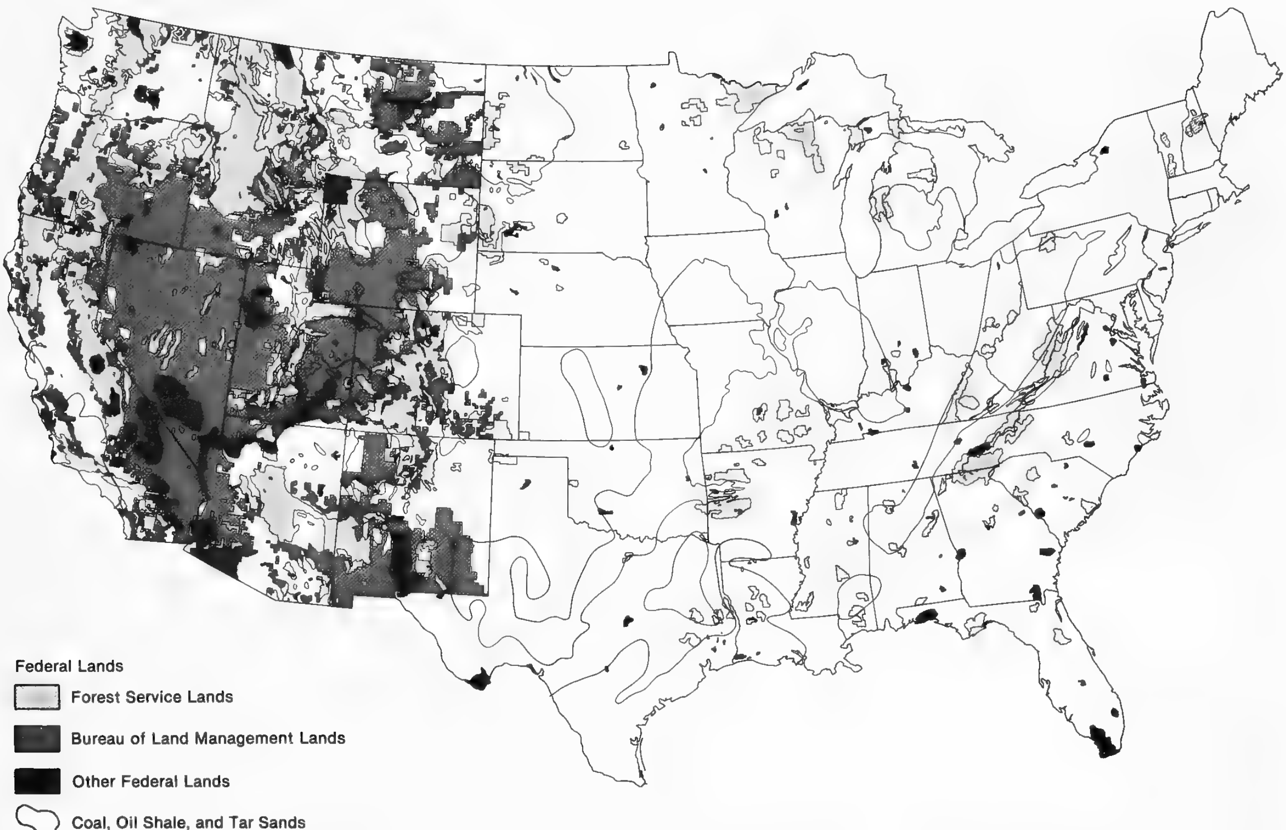
Fuel minerals are by far the most important segment of United States mineral production in terms of value, accounting for 78 percent of the total in 1975. Nonmetals accounted for 14 percent of the total value of production in 1975, and metals made up 8 percent.

United States production and demand for nearly all minerals has been rising. These past trends are likely to continue as shown by projections for some major minerals in table 2.11. Primary production of coal is projected to nearly triple by 2000, rising from about 0.6 billion to 1.7 billion short tons.

Minable coal reserves are about equal east and

Figure 2.4

Geographic Distribution of Coal, Oil Shale, and Tar Sands With Respect to Federally-Owned Lands



west of the 100th meridian. But 44 percent of the western coal can be mined by stripping methods, while only about 19 percent of the eastern coal is strippable. Strippable western coalbeds are typically thick and low in sulfur, making them attractive for mining and for burning where sulfur oxide emissions must be kept low. Eastern coal beds are generally thin and high in sulfur, making them more difficult to mine and use than western coals. Generally, eastern coals are privately owned, whereas the Federal Government owns 60 percent of western coal resources. These facts suggest that, with good transportation facilities and favorable freight rates, Federal coal under western forest and range lands will supply much of the projected demands.

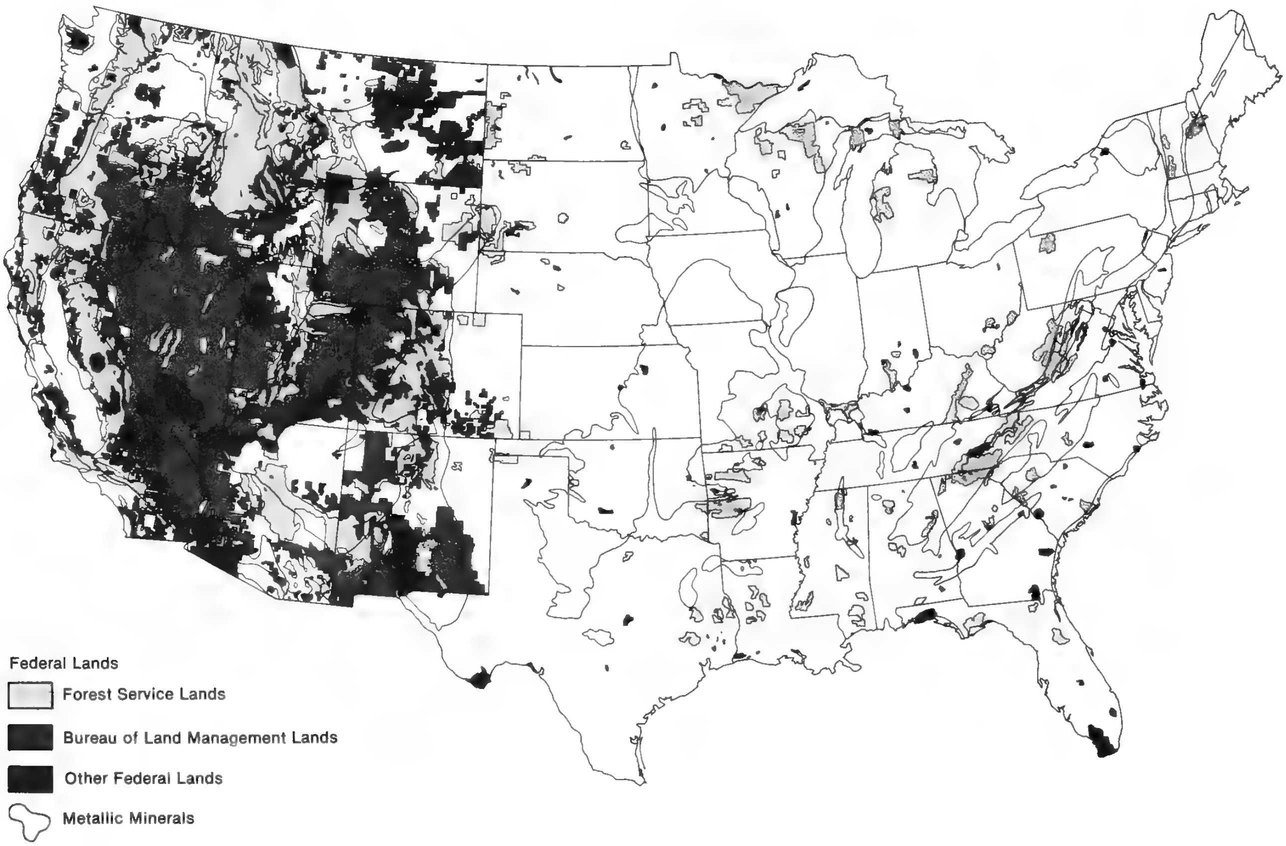
Iron production in 1985 is estimated at 129 million short tons and in 2000 at 159 million short tons. These figures represent production rates 40 percent and 73 percent above 1974. Forested private and State lands in Minnesota, Michigan, and Wisconsin will likely supply the bulk of expected future production. Molybdenum production is also expected to rise sharply in response to domestic and foreign demand. Forest and range lands in Colorado, Arizona, and New Mexico are expected to supply most of the projected production.

Production of nonmetals such as phosphate rock, sand and gravel, and stone is expected to roughly double by 2000. Most of the increase in phosphate rock production is expected to come from Federal forest and range lands in Idaho, Wyoming, Utah, and Montana. Most production of the other nonmetals is expected to come from private forest and range lands and be much more widely distributed geographically.

It is generally acknowledged that Alaska has large mineral deposits, although their magnitude can only be speculated upon. The development of the petroleum fields on the north slope of the Brooks Range is

Figure 2.5

Geographic Distribution of Metallic Minerals With Respect to Federally-Owned Lands



underway, and the oil pipeline completed between Prudhoe Bay and Valdez supplies an estimated 10 percent of the domestic consumption of the United States. The associated gas pipeline is still in the planning stage but, once completed, these fields are expected to supply from 4 to 7 percent of U.S. natural gas consumption by 1990. Additional petroleum fields with commercial potential are believed to exist in other parts of Alaska including the Outer Continental Shelf, but information is lacking as to the size of this resource.

As with most resources in undeveloped regions, there is a strong distinction between physical existence and a viable market. Mineral development is hampered by the uncertainty regarding the quantitative and qualitative aspects of mineral deposits, the inaccessibility of most areas, and the high cost of extraction. Minerals including coal, iron, copper and zinc are known to exist in large quantities, but it is uncertain if they can be competitively developed at this time. Plans are underway to develop the second largest molybdenum deposit known to exist in the world at Quartz Hill in southeast Alaska.

In summation, it seems clear that the Nation is faced with the prospect of a substantial expansion of mining activity. Mining will have impacts on forest and range lands, and uses of forest and range lands will also affect mining activity.

Impacts of mining on forest and range lands — The character of a mineral and its occurrence (liquid, gas, vein, bedded deposit, disseminated body), and the depth at which it occurs determine the method of extraction. Oil and gas are usually produced from wells, although development of methods to get oil from oil shale and gas from coal may lead to mining to obtain these minerals. Coal and other bedded deposits are removed by strip mining where they occur close to the surface and by underground mining else-

where. Phosphate, potash, uranium, and some metals (copper and iron, for example) are often mined in large pits. Many of the metals are typically in ore bodies that are best mined by underground methods. Sand and gravel, dimension stone, clays, and rock for aggregate are usually quarried or mined in open pits.

Impacts of mining on forest and range lands vary greatly depending upon the mineral extraction method. Clearance of vegetation usually amounts to an acre or two per well, less than 100 acres per underground mine, but frequently hundreds or even thousands of acres per surface mine. However, this is necessary to obtain access to the minerals and to protect against fire. In some areas, construction of access roads and other ancillary facilities such as power lines may have greater impacts than the mining itself. Similarly, prospecting for minerals, especially for uranium and other metals, may have greater impacts on the surface than actual mining.

Removal of vegetation obviously affects timber and forage production. It also results in a change of wildlife habitat, often with substantial effects on associated wildlife populations. Impacts on fish habitat can be drastic, too, but it is usually possible to avoid vegetation clearance adjacent to streams and bodies of water. Where this is not possible, mitigation measures are necessary.

Effects of mineral development on air quality and on water yield and quality also vary greatly depending upon the extraction method. Dust, combustion, engine emission, erosion, sedimentation, water pollution, interruption of hydrologic regimes, and reductions in water yield are associated with many mineral operations. These effects tend to be extensive in the case of surface mines and more local with respect to underground mines. Usually, little or no impact is experienced from wells if preventive measures are taken. Preventive and mitigating measures, designed to insure compliance with applicable laws, regulations, and standards, can minimize impacts on air and water resources but cannot eliminate them. Except for the large excavations in bedrock, reclamation is normally required once the mineral operations are completed.

Up to July 1, 1977, it is estimated that more than 5.7 million acres of the United States had been utilized for mining.[12] While this is a large area, it can be put in perspective by noting that mining has disturbed only about 0.25 percent of the land in the United States and that about 40 percent of this has been reclaimed. The data in table 2.12, adapted from a Bureau of Mines publication, shows the relationships between land utilized by mining and land that has been reclaimed during the period 1930-71.[13]

Table 2.13, prepared by the Bureau of Mines, shows cumulative mining areas utilized and reclaimed, by section, region, and State, for the period 1930-71.

Energy resource development, particularly for coal and possibly oil shale, and the mining of copper, sand, gravel, and phosphate rock are likely to have the greatest future impacts on forest and range lands. Over the next few decades, the area disturbed may increase and this disturbance could have important local impacts. However, the area involved should continue to be small relative to the 1.6 billion acres classified as forest and range land. Moreoever, requirements for surface reclamation are becoming more stringent. The Surface Mining Control and Reclamation Act of 1977 (P.L. 95-87), which requires State regulation of surface mining for coal, will affect reclamation on forest and range lands throughout the country. Many States, on their own, have been adopting strict reclamation requirements for coal and other minerals. Woody plant cover is important in stabilization and rehabilitation of disturbed sites for erosion control, amenity values, and timber production. Better methods of revegetating disturbed lands with woody plants are needed for expanded rehabilitation. In addition, integrated pest management systems will be needed to meet quality standards set for protection

Prospecting and access to mining sites may have greater surface impacts than actual mining.

[12] Soil Conservation Service, unpublished estimate, Feb. 1978.

[13] Bureau of Mines, Land utilization and reclamation in the mining industry, 1930-71. I. C. 8642, 54 p. 1974.

Table 2.10—*Value of mineral production in the United States by section, region, and State, 1950, 1960, 1970 and 1975*

(Million dollars)

Section, region and State	1950 Current dollars	1950 1967 dollars[1]	1960 Current dollars	1960 1967 dollars[1]	1970 Current dollars	1970 1967 dollars[1]	1975 Current dollars	1975 1967 dollars[1]	Principal minerals, in order of value
North:									
Northeast:									
Connecticut	5.7	5.4	15.3	15.1	28.4	25.9	33.0	17.5	Stone, sand and gravel, feldspar, lime
Delaware	.5	.5	1.0	1.0	1.6	1.5	1.9	1.0	Sand and gravel, magnesium compounds, clays
Maine	7.5	7.2	13.6	13.4	23.8	21.7	36.7	19.5	Cement, sand and gravel, zinc, stone
Maryland	22.7	21.7	555.5	547.8	88.2	80.3	164.9	87.6	Coal, stone, cement, sand and gravel
Massachusetts	16.0	15.3	27.6	27.2	50.4	45.9	58.8	31.2	Stone, sand and gravel, lime, clays
New Hampshire	1.7	1.6	5.3	5.2	8.7	7.9	17.1	9.1	Sand, and gravel, stone, clays gem stone
New Jersey	46.4	44.3	56.4	55.6	89.3	81.3	123.7	65.7	Stone, sand and gravel, zinc, titanium concentrate
New York	156.5	149.5	254.7	251.2	299.6	272.9	397.7	211.2	Cement, stone, zinc, salt
Pennsylvania	1,186.2	1,133.0	824.5	813.1	1,095.7	997.9	2,907.8	1,544.2	Coal, cement, stone, lime
Rhode Island	1.4	1.3	5.7	5.6	4.4	4.0	6.2	3.3	Sand, and gravel, stone, clays, gem stones
Vermont	18.6	17.8	22.9	22.6	27.8	25.3	28.8	15.3	Stone, sand and gravel, zinc, titanium concentrate
West Virginia	829.6	792.4	720.7	710.7	1,285.4	1,170.7	3,390.2	1,800.4	Coal, natural gas, petroleum, natural gas liquids
Total	2,292.9	2,190.0	2,503.2	2,468.6	3,003.3	2,735.2	7,167.0	3,806.2	
North Central:									
Illinois	488.1	466.2	590.8	582.6	688.7	627.2	1,490.6	791.6	Coal, petroleum, stone, sand and gravel
Indiana	166.6	159.1	206.9	204.0	255.8	233.0	541.6	287.6	Coal, cement, stone, petroleum
Iowa	41.8	39.9	95.0	93.7	120.8	110.0	195.7	103.9	Cement, stone, sand and gravel, coal
Michigan	229.9	219.6	429.1	423.2	670.7	610.8	1,291.7	686.0	Iron ore, petroleum, cement, copper
Minnesota	331.6	316.7	515.3	508.2	633.0	576.5	1,097.1	582.6	Iron ore, sand and gravel, stone, cement
Missouri	113.2	108.1	156.0	153.8	393.0	357.9	722.7	383.8	Lead, cement, stone, iron ore
Ohio	274.6	262.3	389.8	384.4	612.2	557.6	1,356.5	720.4	Coal, petroleum, stone, lime
Wisconsin	41.7	39.8	77.2	76.1	87.7	79.9	132.3	70.3	Sand and gravel, stone, iron ore, cement
Total	1,687.4	1,611.7	2,460.0	2,426.0	3,461.9	3,152.9	6,828.1	3,626.2	
Total, North	3,980.3	3,801.6	4,963.2	4,894.7	6,465.1	5,888.1	13,995.1	7,432.3	
South:									
Southeast:									
Florida	67.7	64.7	176.9	174.5	300.0	273.2	1,775.5	942.9	Phosphate rock, petroleum, stone, cement
Georgia	44.2	42.2	91.2	89.9	203.2	185.1	333.4	177.1	Clays, stone, cement, sand and gravel
North Carolina	26.3	25.1	45.0	44.4	98.4	89.6	152.9	81.2	Stone, phosphate rock, lithium minerals, sand and gravel
South Carolina	11.4	10.9	30.0	29.6	56.4	51.4	115.5	61.3	Cement, stone, sand and gravel, clays
Virginia	137.8	131.6	203.8	201.0	374.3	340.9	1,262.0	670.2	Coal, stone, cement, sand and gravel
Total	287.4	274.5	546.9	539.3	1,032.3	940.2	3,639.2	1,932.7	

South Central:									
Alabama	159.0	151.9	217.6	214.6	323.2	294.4	969.0	514.6	Coal, petroleum, cement, stone
Arkansas	118.6	113.3	155.0	152.9	225.6	205.5	436.4	231.8	Petroleum bromine, natural gas, stone
Kentucky	460.0	439.4	413.5	407.8	847.5	771.9	2,738.9	1,454.5	Coal, petroleum, stone, natural gas
Louisiana	793.6	662.5	1,967.7	1,940.5	5,102.3	4,646.9	8,513.3	4,521.1	Petroleum, natural gas, natural gas liquids, sulfur
Mississippi	102.9	98.3	19.9	19.6	250.0	227.7	410.0	217.7	Petroleum, natural gas, sand and gravel, cement
Oklahoma	527.1	503.4	779.1	768.3	1,137.3	1,035.8	2,267.1	1,204.0	Petroleum, natural gas, natural gas liquids, coal
Tennessee	89.7	85.7	143.4	141.4	220.5	200.8	424.8	225.6	Coal, stone, zinc, cement
Texas	2,674.0	2,554.0	4,134.9	4,077.8	6,402.5	5,831.1	15,529.9	8,247.4	Petroleum, natural gas, natural gas liquids, cement
Total	4,824.9	4,608.3	7,831.1	7,723.0	14,508.8	13,213.8	31,289.4	16,616.8	
Total, South	5,112.3	4,882.8	8,378.1	8,262.4	15,541.1	44,154.0	34,928.6	18,549.4	
Rocky Mtns. and Great Plains:									
Rocky Mtns.:									
Arizona	207.4	198.1	415.8	410.1	1,166.8	1,062.7	1,288.4	684.2	Copper, molybdenum, cement, sand and gravel
Colorado	154.9	147.9	342.2	337.5	389.8	355.0	960.8	510.2	Petroleum, molybdenum, coal, cement
Idaho	79.1	75.5	57.4	56.6	119.8	109.1	233.8	124.2	Phosphate rock, silver, zinc, lead
Montana	103.4	98.8	178.9	176.4	313.0	285.1	573.2	304.4	Petroleum, copper, coal, cement
Nevada	48.5	46.3	80.3	79.2	186.3	169.7	258.4	137.2	Copper, gold, sand and gravel, cement
New Mexico	210.3	200.9	652.2	643.2	1,060.4	965.8	2,091.5	1,110.7	Petroleum, natural gas, copper, potassium salts
Utah	230.0	219.7	431.4	425.4	602.0	548.3	966.4	513.2	Petroleum, copper, coal, gold
Wyoming	177.6	169.6	442.7	436.6	705.5	642.5	1,644.4	873.3	Petroleum, sodium compounds, coal, natural gas
Total, Rocky Mtns.	1,211.2	1,156.8	2,600.9	2,565.0	4,543.6	4,138.2	8,016.9	4,257.4	
Great Plains:									
Kansas	368.6	352.1	484.0	447.3	586.2	533.9	970.6	515.5	Petroleum, natural gas, natural gas liquids, cement
Nebraska	14.0	13.4	103.7	102.3	72.7	66.2	111.9	59.4	Petroleum, cement, sand and gravel, stone
North Dakota	9.6	9.2	78.3	77.2	96.0	87.4	201.5	107.0	Petroleum, cola, sand and gravel, natural gas liquids
South Dakota	32.7	31.2	46.8	46.2	61.6	56.1	101.8	54.1	Gold, cement, stone, sand and gravel
Total, Great Plains	424.9	405.9	712.8	673.0	816.5	743.6	1,385.8	736.0	
Total, Rocky Mtns. and Great Plains	1,636.1	1,562.7	3,313.6	3,268.0	5,360.0	4,881.7	9,402.8	4,993.4	
Pacific Coast:									
Pacific Northwest:									
Alaska	17.9	17.1	21.9	21.6	338.3	308.1	480.7	255.3	Petroleum, natural gas, stone, sand and gravel
Oregon	21.5	20.5	54.4	53.6	68.1	62.0	106.0	56.3	Stone, sand and gravel, cement, nickel
Washington	49.1	46.9	70.0	69.0	90.9	82.8	158.5	84.2	Cement, coal, sand and gravel, stone
Total	88.4	84.4	146.3	144.3	497.3	452.9	745.3	395.8	
Pacific Southwest:									
California	1,056.0	1,008.6	1,402.2	1,382.8	1,897.1	1,727.8	3,152.9	1,674.4	Petroleum, cement, natural gas, sand and gravel
Hawaii	1.8	1.7	9.3	9.2	29.0	26.4	49.7	26.4	Stone, cement, sand and gravel, pumice
Total	1,057.8	1,010.3	1,411.5	1,392.0	1,926.1	1,754.2	3,202.6	1,700.8	
Total, Pacific Coast	1,146.3	1,094.8	1,557.7	1,536.2	2,423.4	2,207.1	3,947.9	2,096.6	
Total, United States	11,874.9	11,341.8	18,212.6	17,961.1	29,789.7	27,130.9	62,274.3	33,071.9	

[1] Derived by dividing the value of minerals production in current dollars by the wholesale price index for crude materials for further processing.
Note: Columns may not add to totals because of rounding.
Source: Department of the Interior, Bureau of Mines, Minerals yearbooks.

Table 2.11 —*Illustrative primary mineral demand-production comparisons in the United States by class of mineral, 1974, with projections to 1985 and 2000*

(Thousand short tons)

Class of mineral	1974		1985		2000	
	Primary demand	Primary production	Primary demand	Primary production	Primary demand	Primary production
Fuels:						
Coal:						
Anthracite	5,000	7,000	5,000	6,000	5,000	6,000
Bituminous and lignite	553,000	603,000	918,000	993,000	1,555,000	1,655,000
Uranium (nuclear)	8	10	41	36	70	60
Metals:						
Copper	1,953	1,597	2,700	2,500	4,200	3,800
Iron content	144,480	91,840	170,240	128,800	204,960	159,040
Nonmetals:						
Clays	59,000	61,000	101,000	100,000	181,000	190,000
Phosphate rock	34,720	45,686	45,000	80,000	69,000	85,000
Sand and gravel	978,000	978,000	1,390,000	1,390,000	2,090,000	2,090,000
Stone, crushed	1,041,000	1,042,000	1,550,000	1,550,000	2,500,000	2,500,000

Source: Department of the Interior, Bureau of Mines, *Mineral trends and forecasts*, 1976.

Table 2.12 —*Area utilized for mining and area reclaimed in the United States by class of mineral, 1930-1971*

(Thousand acres)

Class of mineral	1930-1971	
	Area utilized	Area reclaimed
Fossil fuels:		
Bituminous		
Coal	1,470	1,000
Other	105	14
Total	1,572	1,014
Metals:		
Copper	166	5
Iron ore	108	4
Uranium	13	1
Other	237	33
Total	523	43
Nonmetals:		
Clays	167	59
Phosphate rock	77	12
Sand and gravel	660	197
Stone	516	124
Other	138	14
Total	1,559	406
Total	3,654	1,463

Note: Columns may not add to totals because of rounding.
Source: Department of the Interior, Bureau of Mines, *Information circular 8642* and unpublished data

of watersheds. Reclamation of disturbed land should minimize the impacts of mining on the output of products such as forage and timber.

Impacts of forest and range land uses on mining — While mining has affected uses of forest and range land, the reverse is also true. Use of forest and range lands for wilderness, parks, and other special uses has had significant effects on mineral development. Particular and growing concern has been expressed about restrictions placed on the availability of Federal lands for mineral exploration and development. In recent years, the area of such land open to these activities has dropped substantially. As a result, according to a 1977 report prepared by the Department of the Interior, mineral exploration and development are prohibited, severely restricted, or moderately restricted on two-thirds of all Federal lands.[14] The restrictions comprise three major categories:

1. Classification for disposal pursuant to specific Acts of Congress.
2. Withdrawal specifically to protect against impacts associated with mineral exploration and development.
3. Reservation (dedication) for a particular public purpose or use.

Much of the recent reduction has been in Alaska. As lands are finally classified and reserved pursuant to the Alaska Native Claims Settlement Act, some Alaska lands presently unavailable will be opened for mineral development. But, elsewhere, future wilderness designations seem likely to result in even further reductions in land available for mineral development.

[14] U.S. Department of the Interior, Final report of the task force on the availability of Federally-owned lands, 43 p. 1977.

Table 2.13—*Area[1] utilized for mining and area reclaimed in the United States by class of mineral, section, region, and State, 1930-1971*
(Thousand acres)

Section, region, and State	Total		Fossil fuels[2]		Metals		Nonmetals	
	Area utilized	Area reclaimed	Area utilized	Area reclaimed	Area utilized	Area reclaimed	Area utilized	Area reclaimed
North:								
Northeast:								
Connecticut	12.3	3.4	0.1	(3)	—	—	12.2	3.4
Delaware	1.3	.4	—	—	—	—	1.3	.4
Maine	10.6	3.2	.2	.1	(3)	(3)	10.4	3.1
Maryland	25.6	9.2	4.6	3.4	(3)	—	21.0	5.8
Massachusetts	20.3	5.6	—	—	(3)	—	20.3	5.6
New Hampshire	5.3	1.6	—	—	—	—	5.3	1.6
New Jersey	28.4	7.5	.7	.1	3.0	.3	24.7	7.1
New York	96.3	24.6	(3)	—	26.6	4.0	6.7	20.6
Pennsylvania	381.0	186.3	344.0	175.0	1.1	.1	35.5	11.2
Rhode Island	2.3	.5	—	—	.1	(3)	2.3	.5
Vermont	7.4	1.2	—	—	3.3	.2	4.1	1.0
West Virginia	210.2	104.8	196.0	101.0	—	—	14.2	3.8
Total	800.7	348.2	545.6	279.5	34.1	4.7	221.0	64.1
North Central:								
Illinois	296.9	188.9	235.0	171.0	.3	(3)	61.6	17.9
Indiana	175.0	113.0	131.0	101.0	—	—	44.0	12.0
Iowa	55.3	18.3	8.8	6.3	—	—	46.5	12.0
Michigan	99.5	24.1	3.1	.8	10.5	.4	85.9	22.9
Minnesota	136.0	13.0	.1	(3)	103.0	3.4	32.9	9.6
Missouri	102.3	41.4	33.5	26.9	23.1	2.8	45.7	11.7
Ohio	291.6	181.2	207.0	157.0	—	—	84.6	24.2
Wisconsin	46.9	12.4	.1	(3)	2.3	.1	44.5	12.2
Total	1,203.5	592.3	618.6	463.1	139.2	6.7	445.7	122.5
Total, North	2,004.2	940.5	1,164.2	742.6	173.3	11.3	666.7	186.6
South:								
Southeast:								
Florida	88.9	17.0	.7	.1	10.4	1.9	77.7	15.1
Georgia	34.3	9.6	.1	(3)	.9	.2	33.3	9.4
North Carolina	36.6	9.6	—	—	1.4	.1	35.2	9.5
South Carolina	14.6	4.1	.1	(3)	.1	(3)	14.4	4.1
Virginia	78.8	28.9	34.8	19.0	2.3	.4	41.7	9.5
Total	253.1	69.3	35.7	19.1	15.1	2.6	202.3	47.6
South Central:								
Alabama	65.1	28.6	34.9	21.8	7.7	.3	22.5	6.4
Arkansas	29.5	9.0	3.1	2.1	3.7	.9	22.7	6.0
Kentucky	233.9	149.4	210.0	143.0	.1	(3)	23.8	6.4
Louisiana	18.2	5.2	—	—	—	—	18.2	5.2
Mississippi	10.7	3.3	—	—	—	—	10.7	3.3
Oklahoma	35.5	16.5	13.8	10.9	.9	.3	20.8	5.3
Tennessee	67.8	23.4	17.9	12.2	3.2	.3	46.7	10.9
Texas	78.0	20.5	.8	.5	4.5	.4	72.7	19.6
Total	538.6	256.0	280.5	190.5	20.0	2.3	238.1	63.2
Total, South	791.7	325.3	316.1	209.6	35.2	4.9	440.4	110.8

See footnote at end of table.

Table 2.13—*Area[1] utilized for mining and area reclaimed in the United States by class of mineral, section, region, and State, 1930-1971 (continued)*

(Thousand acres)

Section, region, and State	Total		Fossil fuels[2]		Metals		Nonmetals	
	Area utilized	Area reclaimed	Area utilized	Area reclaimed	Area utilized	Area reclaimed	Area utilized	Area reclaimed
Rocky Mountain and Great Plains:								
Rocky Mountain:								
Arizona	102.3	6.8	.2	.1	86.2	2.5	15.9	4.2
Colorado	48.8	14.1	8.9	4.8	17.4	3.5	22.5	5.8
Idaho	41.2	8.6	(3)	(3)	21.6	3.4	19.6	5.2
Montana	42.8	10.6	6.9	3.7	15.7	1.2	20.2	5.7
Nevada	41.2	4.1	—	—	29.1	1.6	12.1	2.5
New Mexico	47.8	9.8	8.6	6.0	21.8	.8	17.4	3.0
Utah	66.7	6.3	3.2	.3	48.9	2.1	14.6	3.9
Wyoming	28.4	9.0	10.1	4.8	5.8	.4	12.5	3.8
Total, Rocky Mountain	419.2	69.3	37.9	19.7	246.5	15.5	134.8	34.1
Great Plains:								
Kansas	44.0	21.5	19.7	15.7	6.1	.5	18.2	5.3
Nebraska	12.8	3.7	—	—	—	—	12.8	3.7
North Dakota	35.1	23.9	27.3	21.6	(3)	(3)	7.8	2.3
South Dakota	16.5	4.6	.3	.2	1.4	.1	14.8	4.3
Total, Great Plains	108.4	53.7	47.3	37.5	7.5	.6	53.6	15.6
Total, Rocky Mountain and Great Plains:	527.6	123.0	85.2	57.2	254.0	16.1	188.4	49.7
Pacific Coast:								
Pacific Northwest:								
Alaska	29.6	10.7	3.6	3.3	16.1	4.4	9.9	3.0
Oregon	34.0	8.9	(3)	(3)	5.5	1.3	28.5	7.7
Washington	35.9	9.7	2.0	.6	1.4	.1	32.6	9.0
Total	99.6	29.3	5.6	3.9	23.0	5.8	71.0	19.7
Pacific Southwest:								
California	226.5	43.9	.5	.1	38.0	5.3	188.0	38.5
Hawaii	4.8	1.2	—	—	—	—	4.8	1.2
Total	231.3	45.1	.5	.1	38.0	5.3	192.8	39.7
Total, Pacific Coast	330.9	74.4	6.1	4.0	61.0	11.1	263.8	59.3
Total, United States	3,654.3	1,463.2	1.571.6	1,031.6	523.4	43.3	1,559.3	406.3

[1]Includes surface mine excavation area used for disposal of surface mine waste, surface area subsided or disturbed as a result of underground workings, surface area used for disposal of underground waste, and surface area used for disposal of mill or processing waste.

[2]Excludes oil and gas operations.

[3]Less than 50,000 acres.

Note: Columns may not add to totals because of rounding.

Source: Department of Interior, Bureau of Mines *Information Circular 8642* and unpublished data.

Urban Forests

Although the great bulk of the Nation's forest and range lands is in rural areas, there are lands in the urbanized parts of the country with many of the same characteristics as rural forest and range lands and used for many of the same purposes. They contribute to soil and water conservation, provide habitat for wildlife and sites for many kinds of outdoor recreation, and upgrade the environment and the quality of life in urban environments.

These lands, frequently called urban forests, include greenbelts, buffer strips, roadside forests, community parks, and wooded residential and industrial zones. There is no readily available information that defines the extent and location of urban forests in the United States. Interest in such areas and their management, however, has grown to the point where urban forestry is now recognized as an area of study in some universities and in programs of Federal and State agencies. Federal commitment and concern for urban forestry issues is evident in the urban forestry research effort of the Pinchot Institute for Environmental Forestry Research at the Northeastern Forest Experiment Station and in the Human and Community Development Element of the Forest Service Program.[15] [16]

Urban forests and open space can be looked to as a resource in meeting some of the outdoor recreation, wildlife, and environmental needs of the future. They are located close to population centers and can be especially important in meeting the needs of those who are unable, for one reason for another, to use more distant forest and range lands.

Wetlands

As a category of land that is part of the Nation's forest and range land base, wetlands deserve special attention because of their high biological productivity and their importance as habitat for wildlife and fish at critical times in their life cycles. Wetlands include swamps, marshes, bogs, sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds and support vegetation that requires saturated soils for at least part of the year.[17]

[15] Forest Service. The Pinchot Institute system for environmental forestry studies. Gen. Tech. Rep. NE 2, Northeast. For. Exp. Sta., Upper Darby, Pa., 60 p. 1973.

[16] Riddle, J. R., G. H. Moeller and W. H. Smith. Breaking new ground in urban America. American Forests, 82(11):26-30, 66. 1976.

[17] Executive Order 11990, Protection of Wetlands, May 24, 1977, Federal Register, 42(101), Wednesday, May 25, 1977.

Most of these wetland areas are also classed as forest or range lands. Salt marshes along the Atlantic Coast; spruce bogs in Maine, the Lake States, and Alaska; and prairie potholes in the Great Plains are all wetland components of forest or range lands. The particular value of wetlands derives from their importance as breeding areas for wildlife and fish; as sources of water for wildlife and livestock; and, despite their generally high productivity, as environmentally sensitive areas. Disruption of the water regime of wetlands can affect water tables and hydrologic conditions in surrounding areas. In addition, disturbance of soil and vegetation in wetlands can lead to stream sedimentation and loss of fragile ecosystems that are important for fish breeding.

Several national wetlands inventories have been conducted beginning with an inventory by the U.S. Department of Agriculture in 1906. These inventories have shown conclusively that wetland acreages are declining. The Soil Conservation Service has estimated that there were once 127 million acres of wetlands in the United States.[18] This had declined to 82 million acres by 1953.[19] Continued drainage, flood control, and related activities since that time have undoubtedly reduced the wetland area even more.

Concern over loss of wetlands has led a number of States to pass wetlands protection laws. These laws generally prohibit or restrict filling and other actions in wetlands that are detrimental to waterflows and to the ability of the wetlands to sustain wildlife and fish populations. Their overall impact in reducing the loss of wetlands in the face of major drainage programs and reservoir construction has been limited, however. Protection of remaining wetlands is an important land management objective for both private and public lands.

The normal uses of forest and range lands in wetlands areas, including timber harvesting and grazing of domestic livestock, are compatible with wetlands protection objectives as long as reasonable care is exercised. The wet grassland ecosystem, most of which occurs in wetlands, is the most productive range ecosystem. Some forested wetlands, such as bottomlands in the Mississippi Delta and along the Southeast Atlantic Coast, are highly productive for valuable hardwood timber species. Restricting logging and grazing during certain times of the year and minimizing construction of logging roads or other soil-moving activities will minimize the impacts of logging and grazing on these lands.

[18] Shaw, S. P., and C. G. Fredine. Wetlands of the United States, U.S. Department of Interior, Fish and Wildlife Service Circ. 39. 1971.

[19] Wooten, H. H. Major uses of land in the United States. U.S. Department of Agriculture, Tech. Bull. 1082. 1953.

Air pollution, such as that evident here, can damage forests and rangelands up to 70 miles from the source.

Air

Air is a resource that significantly affects and is affected by the Nation's forest and range lands.

Impacts of air on forest and range lands— Air is made up of many constituents that originate from natural and unnatural sources. These constituents eventually are deposited on the soil, vegetation, and waters of the earth. Constituents causing undesirable effects on living organisms or materials are called pollutants. Air pollution is most common in industrialized population centers and the forest and range lands nearest these centers are most likely to be damaged. Pollution from some urban and industrial sites has caused reductions in growth, increased susceptibility to insect attack, and death to some vegetation more than 70 miles distant.

Most of the Nation's forest and range lands are in areas of low population densities and have relatively good air quality. Even so, air pollutants, transported over long distances from urban and industrial centers, have direct adverse effects. Of major national and international importance is acid precipitation, caused by oxidation in the atmosphere of sulphur and nitrogen oxides. Acid precipitation is now causing adverse impacts on sensitive aquatic life, soils, and vegetation, particularly in the northeastern United

States. Increased energy production from fossil fuels has the potential for increasing these impacts and extending them to other areas of the country. A 10-year accelerated study of this problem has been recently proposed by the President.

Air pollution affects scenic values of some forest and range lands. Thirty million acres of Federally owned land in 37 States has been designated by Congress for special protection of visibility and other air quality-related values. Protecting these lands will have indirect impacts because major emitting facilities will not be permitted to locate in any area where adverse effects may result on these Federal lands.

Impacts of forest and range lands on air — Natural emissions from forest and range lands vegetation contributes to the composition of the air resource. Plants exchange compounds with the air. For example, an elm tree of medium size will give off 15,000 pounds of water on a clear, dry, hot day. Millions of tons of hydrocarbons are emitted into the air daily from decomposing plant materials and living plants. Wildfires emit thousands of tons of particulates and other matter into the air each year, reducing visibility in broad areas of the Nation.

Other emission sources from forest and range lands are associated with production of goods and services. Fire is used intentionally on large areas under certain environmental conditions to manage vegetation for wildlife habitat, insect and disease control, wildfire prevention, timber production, and other objectives. Emissions from these fires are significant, but can be managed to minimize adverse effects. Roads and their attendant traffic and off-road vehicles and equipment used for logging, mining, and recreation produce emissions, but to a lesser extent than fire. In the future as the intensity of use of forest and range lands grows, greater efforts may be necessary to control undesirable emissions.

Summary

The Nation's forest and range lands, in their great variety, support a broad array of uses that are important to the economy and to general social well-being of the Nation. As the population grows, and incomes and tastes change, the demands for these resources will also grow and change. As long as the inherent productivity of these lands is protected and maintained, they can be managed to provide increased amounts of practically all resources and uses.

Almost every one of the 1.6 billion acres of forest and range lands now provides two or more major outputs — outdoor recreation range for domestic livestock, timber, water, wilderness, and wildlife and fish. On much of the land multiple-use takes place with no apparent conflict among resource uses; on many other areas, conflicts among uses are minimized through careful management.

As demands for the resources on these lands increase, however, the intensity of management and regulation of use must also increase to cope with the inevitable intensification of conflicts among alternative uses. In some instances, one important use will have to give way to another. The purpose of this report is to provide information to facilitate the efficient allocation of the Nation's forest, range, and related water resources.

The following chapters will provide information on the likely trends in the demands for each of the major uses of forest and range lands and will assess the capability of these lands to satisfy expected demands. Although major uses are discussed separately, it must be borne in mind that they take place on the ground in a myriad of overlapping combinations. No resource or use can be examined in isolation and without consideration of other resources and uses on the same limited areas. Every effort has been made to keep this salient feature of the use of forest and range lands in view throughout this report. The great challenge facing the owners and managers of private and public forest and range lands is the integrated management of all of these resources.

Chapter 3. — Outdoor Recreation and Wilderness

This chapter presents information on: (1) Current economic and social demands for outdoor recreation and wilderness and projected participation trends to 2030; (2) the current supply of outdoor recreation and wilderness opportunities; (3) a comparison of projected demands and supplies and the socioeconomic implications of those comparisons; and (4) opportunities for increasing and enhancing the outdoor recreational and wilderness experiences obtainable on forest and range lands.

For the purposes of this assessment, outdoor recreation opportunities are defined as those natural and cultural resources on forest and range lands that are used by people during their leisure time to enjoy or obtain a change of pace, a change of social environment, and other physical or psychic satisfactions. These resources involve both the natural environments and manmade facilities, including the visual features of an area that affect the esthetic quality of a visitor's recreational experience.

The demand and supply of outdoor recreation resources are evaluated in terms of recreational activities.

These activities are grouped into three classes to differentiate among important management opportunities and resource characteristics:

Land activities — The large forest and range land base provides opportunities for people to enjoy their recreational pursuits in dispersed or relatively undeveloped settings. Many of the activities enjoyed on these lands center around travel methods, including hiking, horseback riding, automobile driving, and off-road vehicle travel. While these activities are frequently pursued for their own sakes, they also make other recreation opportunities possible, including both primitive and roadside camping, sightseeing, fishing, hunting, and nature study.

In addition, development of forest and range lands has provided people with an expanded range of recreation opportunities. On private lands, recreational home development enables an increasing number of people to enjoy the scenic and recreational values of forest and range lands. On public lands, recreational use is often concentrated around travel routes and special scenic or recreational features; frequently service facilities are constructed in these areas to enhance the comfort, convenience, and safety of the visiting public.

Water activities — Water is a prime attraction for recreational activities. People use rivers, lakes, and other wetlands for a wide variety of recreational activities. Many are directly water-based such as swimming, fishing, boating, and kayaking. Others, such as camping, hiking, driving for pleasure, picnicking, and relaxing are often pursued with water as an important backdrop.

Snow and ice activities — The occurrence of snow and ice on forest and range lands broadens the range of recreational opportunities. They include such activities as downhill skiing, snowmobiling, cross-country skiing, and snow play. Forested areas, roads, and cleared sites that may not be particularly attractive for recreation during the summer often assume added recreational value with the presence of snow and ice. Logging roads covered with snow, for instance, are highly suitable for both snowmobiles and cross-country ski trails.

Outdoor Recreation

No national surveys have been conducted of outdoor recreation participation or expenditures specifically on the Nation's forest and range lands. However, significant insights can be gained from the 1977 National Outdoor Recreation Survey conducted by Heritage, Conservation and Recreation Service.[1] The survey consisted of personal interviews with members of 4,029 randomly selected households distributed throughout the contiguous United States. The survey focused on what people said they did, the frequency of their participation, and other factors influencing their outdoor recreation activity.

Consistent with the findings from previous national recreation surveys, the 1977 National Outdoor Recreation Survey reported that the activities people said they participated in most were picnicking, sightseeing, swimming, and driving for pleasure (table 3.1). For many of the activities, the majority of the respondents said they participated more than four times in 1977, while smaller percentages had just begun to participate or indicated a desire to do so. A few of these activities that had lower participation rates tended to be the ones which people said they were most interested in trying. These pursuits included snow skiing, water skiing, and horseback riding.

In terms of regional participation, individuals from the Pacific Coast, Rocky Mountain, and Great Plains States were more likely to participate in outdoor recreation activities. In particular, more westerners participated in such activities as camping, backpacking, and skiing than the residents of other regions of the country. Individuals in the North were more frequent participants than westerners in ice skating, snowmobiling, and sledding, as well as swimming and canoeing; southerners, on the other hand, participated as much or more than recreationists in western

[1] U.S. Department of the Interior, Heritage, Conservation and Recreation Service. 1977 National Outdoor Recreation Survey. (In process).

Picknicking, swimming, and sledding are the most popular
land-based, water-based, and snow and ice recreation activities, respectively.

States in such pursuits as water skiing, driving for pleasure, hunting, and fishing.

The National Outdoor Recreation Survey also revealed that most participants come from metropolitan areas and high- or middle-income groups. Also, a larger share of the participants was in the 18-44 age group than in any other group.

Trends in Participation in Outdoor Recreation

Participation in most types of outdoor recreation has been growing rapidly based on national participation surveys, industry reports, and managing agency records. For example, participation in outdoor recreation on National Forests has increased by 37 percent over the last decade. Many factors are responsible, but they all relate to increased growth in population, higher incomes, increased mobility, more leisure time, improved technology, better access to recreational areas, and better information for recreationists about where to go and what to do in the out-of-doors.

The most rapid increases in outdoor recreational participation have been in snow and ice activities. New and improved facilities, equipment, and lightweight winter clothing, and a rediscovery of the enjoyment that cold weather activities can provide have resulted in year-round participation in regions where outdoor recreation was once largely limited to the summer season.

One significant indicator of the expanding interest in snow and ice activities is increasing participation in cross-country skiing. Public land managers and industry spokesmen agree that the number of these skiers has at least tripled over the last few years. Sales of cross-country skis also confirm these estimates. In contrast to a decade ago, when only 12,000 cross-country skis were imported annually and none were manufactured in the United States, imports now amount to 50,000 skis each year, and one United States company alone produces 250,000 skis annually.

Participation in water activities has likewise increased substantially in all regions of the country in recent years.[2] Indicators of the growing use of waterways for recreation include the Boating Industry

[2] U.S. Department of Transportation, U.S. Coast Guard. Recreational Boating in the Continental United States in 1973 and 1976; The nationwide boating survey. Washington, D.C. 1978.

Table 3.1 — *Percent of households participating in outdoor recreation in the United States by type of activity, 1977*
(Percent)

Activity group and type of activity	Participating at least once	Participating more more than four times	Having just started	Wanting to participate in future
Land:				
Camping (developed)	30	12	1	2
Camping (dispersed)	21	9	—	3
Driving off-road vehicles	26	20	1	1
Hiking	28	16	1	2
Horseback riding	15	8	1	4
Nature study/photography	50	36	1	1
Picnicking	72	49	—	—
Pleasure driving	69	57	2	—
Sightseeing	62	36	1	1
Water:				
Canoeing	16	5	1	2
Sailing	11	5	1	3
Other boating	34	20	1	2
Swimming outdoors	61	47	1	1
Water skiing	16	8	2	5
Snow and ice:				
Cross-country skiing	2	1	1	4
Downhill skiing	7	4	1	6
Ice skating	16	9	—	2
Sledding	21	12	—	1
Snowmobiling	8	5	1	3

Source: U.S. Department of Interior, Heritage, Conservation, and Recreation Service. *1977 National outdoor recreation plan.* (In process).

Magazine's[3] estimates that nearly 0.6 million new boats were purchased in 1977. Estimates of canoe sales (excluding kayaks), nationwide, rose from 35,000 in 1966, to 82,000 in 1977. Furthermore, increasing memberships in river-related organizations, sponsored river events, and river-oriented magazine circulation all point to growing water-based recreational activity. Memberships in the American Canoe Association climbed from 1,000 in 1965, to over 5,000 by 1976. The number of Sierra Club river outings has more than doubled since 1969. Circulation of Canoe Magazine, which began in 1973 with 5,000 subscribers, had increased to over 30,000 in 1977.

Similarly participation increases have been reported for both developed and dispersed land activities. For instance, more than 39 million recreation visitor days were spent in National Forest campgrounds in 1977, representing a 29 percent increase over the last decade. Similar trends have been reported by Kampgrounds of America and Nielsen in their national participation surveys.[4] A specific indicator of the expanding interest and participation in dispersed land recreation is the growth of the use of National Forest trails for hiking, which grew from 5.8 million recreation visitor days in 1975, to 6.4 million in 1977. The Appalachian National Scenic Trail, in particular, experienced a 35 percent increase in recreation use between 1974 and 1976.

As participation has grown rapidly, so have expenditures for outdoor recreation. Estimates of total expenditures for the leisure and recreation market vary depending on the breadth of the categories of goods and services included. The Department of Commerce's Bureau of Economic Analysis reports a figure for direct recreation expenditures of almost $93.2 billion in 1977, or 7.0 percent of total personal consumption expenditures.[5] These expenditures, which do not include significant indirect expenditures associated with recreational participation, such as travel costs and licenses, represent an increase of nearly $48 billion, or 110 percent since 1970.

Other estimates of direct recreational expenditures are even higher. According to an industry analyst with the Department of Commerce's Office of Consumer Goods and Services, $160 billion was spent in 1977 on recreational equipment, sporting goods, admissions and dues, and $60.2 billion on vacations and trips in the United States.[6,7] The $160.2 billion represents in increase of 9.2 percent over the office's 1976 figure of $146.5 billion and a 125 percent increase over the 1967 spending levels.

Outdoor Recreation Demand

Traditionally, outdoor recreation has been predominantly a public good, in that market values have been largely nonexistent for many outputs of outdoor recreation. The last few decades, however, have seen greater involvement of the private sector in providing outdoor recreational activities. Increasingly, sentiment in the public sector has favored leaving the development of more capital-intensive, convenience-oriented facilities to the private sector. Growing emphasis on the complementary nature of public and private supplies of outdoor recreation has contributed to the expansion of the private sector's role in meeting recreation demand.

The principal outdoor recreational activities now commonly provided through the private sector are those requiring highly developed areas such as marinas, campgrounds, and skiing facilities (both downhill and cross-country). Private enterprise also makes a significant contribution to the supply of recreational facilities and services on public lands through concessionaire and outfitter operations. Goods and services provided by such enterprises include food and lodging and various types of such guided trips as horseback riding, fishing, and river-rafting.

Despite the existence of markets for some outdoor recreation services, outdoor recreation on forest and range lands remains predominantly a nonmarket good. To provide long term estimates, outdoor recreation "demand" is assessed in this chapter in terms of projected participation levels. The projections presented are the expected number of participants in various activities as an index of the future quantities demanded.[8]

[3] Personal communication (P. Glauckman, Boating Industry Magazine staff, Aug. 1979).

[4] Kampgrounds of America. 1976 camper survey. Billings, Mont. 1976; and A. C. Nielsen Company. The boom in leisure — Where. U.S. News and World Report, May 23, 1977.

[5] U.S. Department of Commerce, Bureau of Economic Analysis. Survey of current business, July, 1978. Washington, D.C. 64 p. 1978.

[6] Owne, Elizabeth. The magnitude and general characteristics of the recreation industry. Speech presented at the Oklahoma Recreation and Tourism Conference. Oklahoma City, Okla. Feb. 22, 1978.

[7] Browth, Irwin and Associates. Sporting goods markets in 1979. National Sporting Goods Association, Chicago, Ill. 1979.

[8] Because of the lack of reliable national trend data on participation in most outdoor recreation activities, estimates were developed using a cross-sectional regression analysis of the 1977 Outdoor Recreation Survey. Equations were developed which relate a set of explanatory variables to the probability that the average American will participate in a given activity and these equations were used to project participation through time with prices and quantities supplied determined external to the model. For details of procedures used, see John G. Hof. "Projection and evaluation of outdoor recreation use of forest lands." Colorado State University, PhD. Thesis. 209 p. 1979.

Determinants of demand for outdoor recreation — Growth in population and income of the magnitudes assumed in the assessment will obviously have an upward influence on the future participation in outdoor recreation activities. In addition, a number of other factors will likely influence future participation levels, particularly in such activities as downhill skiing, sightseeing, and camping. Based on information for the Office of Consumer Goods and Service Industries, Americans are increasingly enjoying their affluence in the form of more leisure.[9] Individual workers received an average of 16 days vacation annually, the highest average in history. Leisure also increased for all workers measured in the period 1965-1975, regardless of whether the individual was male or female, married or single.[10] For instance, working married men increased their leisure time from 33.7 to 36.1 hours each week. Similarly, employed married women increased their weekly leisure from 26.7 hours in 1965, to 31.7 hours in 1975.

Increasing participation by women in outdoor recreational activities should also continue to affect total outdoor recreational participation. As early as a decade ago, sports and outdoor recreational activities, especially the active ones, were almost entirely male-oriented. However, the interest of women in exercise and outdoor activities is growing rapidly. In the 1971-1975 period, the National Federation of State High School Associations found dramatic increases in the numbers of women participating in golf, skiing, and tennis competitions.[11] Increasing numbers of women are single, lack family obligations, and have incomes. Such factors have contributed to more than doubling participation by women since 1970 in such activities as cross-country skiing, fishing, hunting, and scuba diving. Nonetheless, participations rates for women in outdoor recreational activities can still increase substantially before they equal rates for men.

Some factors, however, are expected to reduce the rate of growth in participation. One influence expected to dampen future participation, especially for strenuous activities such as backpacking, water skiing, and primitive camping, is the general aging of the population. America's population is growing significantly older. Whereas, the median age was 29.4 in 1977, in 1990 it is projected to be 32.8, and by 2030, it is expected to reach 39.9. Since older individuals tend to participate less in strenuous activities and to be more selective in the choice of activities in general, participation rates are expected to fall with age.

Perhaps a major factor contributing to the phenomenon, beyond the normal aging process, has been the physical inactivity of many Americans; 43 percent of all American adults, according to a recent poll, never exercise.[12] However, this situation may be changing. It is estimated that over 6 million Americans, including the President, have started running or jogging in the 3-year period from 1975-1978, and organized exercise programs appear to be growing in popularity.

Another factor which may dampen outdoor recreational participation is rising energy costs and the possibility of future increases in participation fees — on both public and private recreational areas. Inexpensive or free recreation opportunities have been a key factor in the growth in outdoor recreation participation. Although recreation participation has been relatively insensitive to cost changes in the past,[13] future increases in travel costs, caused by rising energy prices and potential fee increases, may significantly affect demands — especially where long-distance travel is involved.

National projections of demand — Projected participation levels based on the above considerations and the assumed increases in population, economic activity, and income used in this study are shown in table 3.2. In general, the snow and ice activities show the most pronounced increases in participation. While there are some indications that the growth rates of downhill skiing and snowmobiling have slowed from the rates experienced in the 1960's and early 1970's, participation in these and other snow and ice activities is projected to increase 140 percent by 2030. Downhill skiing and cross-country skiing show some of the largest increases among all activities.

Participation for water activities is also projected to increase fairly rapidly, with sailing and canoeing showing large growth. It is anticipated that water activities, as a group, will increase 106 percent by 2030. Water activities attract a broad cross-section of the population, although regional differences in participation do exist for some activities. People living in the North are more likely to participate in canoeing and sailing, while those located in the South, Pacific

[9] Owen, E. The growth of leisure markets and its impact on the U.S. economy. The Office of Consumer Goods and Services Industries, U.S. Department of Commerce. 1978. (In process).

[10] Robinson, J. Change in Americans' use of time: 1965-1975, A Progress Report, Communication Research Center, Cleveland State University. 1977.

[11] A. C. Nielsen Survey, National Tennis Foundation. Comes the revolution. Time. Jul. 26, 1978.

[12] The Fitness Mania. U.S. News and World Report. Feb. 27, 1978.

[13] U.S. Department of Transportation, Federal Highway Administration. Recreational travel impacts. Washington, D.C. 171 p. 1978.

Coast, and Rocky Mountain and Great Plains States are more frequent participants in motor boating and water skiing.

Projections for land activities also suggest that participation will continue to increase by 61 percent (table 3.2, fig. 3.1). However, except for developed and dispersed camping, which are projected to increase more than those for several water and snow and ice activities, comparative increases in participation in land activities tend to be modest. Nonetheless, the feelings of independence and individuality, adventure, and self-sufficiency, which many land activities can provide, should ensure their continuing popularity.

The projections are sensitive in the long run to changes in such variables as population levels, economic activity, and income. For instance, under the low-level assumptions made with respect to these determinants, developed camping is projected to increase only 81 percent by 2030; under the high level assumptions, it is expected to increase 269 percent (table 3.2). However, in the short run, the projections are rather insensitive to assumed changes in population and income. For example, if the rate of increase in the gross national product in the 1977-90 years were reduced by 1.0 percent, the medium projected demand for outdoor recreation in 1990 would only be reduced by about 2 percent.

Regional projections of demand— Projections of participation in outdoor recreation vary widely from region to region (table 3.3). The projections for land activities indicate large increases in participation in the South and Pacific Southwest, with more modest increases in the Northeast and North Central regions. For snow activities, most regions in the North and West exhibit increases, especially the Pacific Southwest region. The increase in participation in water activities, by comparison, is more even across the different regions.

Two key factors account for much of the variation among regions. One important component is the regional characteristics of the forest and range resource. For instance, Rocky Mountain States have terrain and climate for downhill skiing superior to that in many other States. A second factor is the basic assumption that the population will continue to migrate to the sunbelt. This migration contributes to comparative increases in participation for the Pacific Southwest, southern Rocky Mountains, and southern States. For example, the Phoenix-Tucson area in Arizona and the Front Range area in Colorado, which stretches from Fort Collins in the north to Pueblo in the south, are expected to grow at rates substantially above national levels.

Figure 3.1

Projections of Demand for Outdoor Recreation

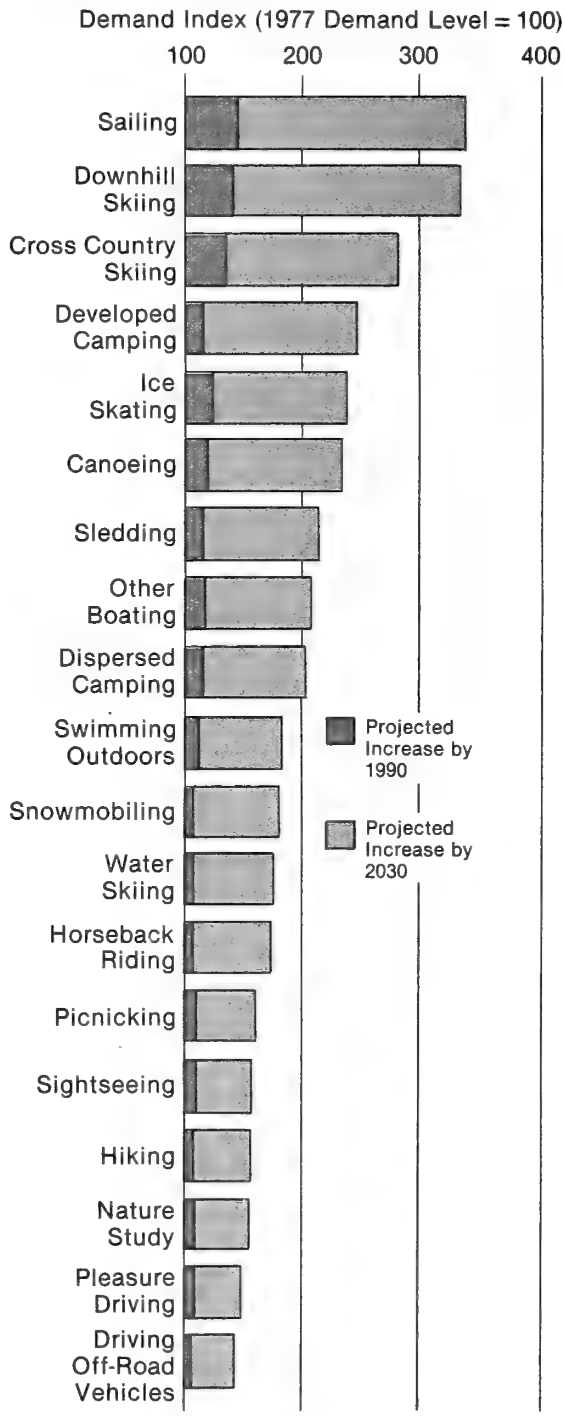


Table 3.2 — *Indexes of demand for outdoor recreation in the contiguous States by activity group and type of activity, 1977, with projections to 2030*

(1977 × 100)

Activity group and type of activity	Projection level[1]	Projections					
		1977	1990	2000	2010	2020	2030
Population index[2]	Medium	100	112	120	127	134	139
Land:	High	100	122	144	175	208	245
	Medium	110	111	121	135	149	161
	Low	100	105	109	113	118	120
Camping (developed)	High	100	139	180	236	297	369
	Medium	100	116	150	181	214	245
	Low	100	118	133	149	167	181
Camping (dispersed)	High	100	130	161	207	254	311
	Medium	100	116	133	157	182	205
	Low	100	111	121	132	145	155
Driving off-road vehicles	High	100	118	134	154	177	201
	Medium	100	108	118	128	139	147
	Low	100	108	115	120	125	126
Hiking	High	100	124	149	137	225	270
	Medium	100	109	117	132	146	159
	Low	100	101	102	103	107	109
Horseback riding	High	100	125	151	194	233	284
	Medium	100	109	118	137	155	173
	Low	100	102	102	105	113	119
Nature study	High	100	123	146	176	210	247
	Medium	100	110	110	133	145	155
	Low	100	106	111	117	125	131
Picnicking	High	100	119	140	166	196	230
	Medium	100	112	124	137	150	162
	Low	100	107	114	119	125	127
Pleasure driving	High	100	118	136	159	186	215
	Medium	100	110	120	130	141	149
	Low	100	105	111	114	117	118
Sightseeing	High	100	121	143	171	202	237
	Medium	100	112	123	136	148	159
	Low	100	105	111	115	118	120
Water:	High	100	131	164	218	261	322
	Medium	100	118	134	158	181	206
	Low	100	108	115	124	134	144
Canoeing	High	100	140	182	243	305	384
	Medium	100	121	140	170	200	233
	Low	100	109	117	128	141	155
Sailing	High	100	159	221	305	396	511
	Medium	100	144	182	231	281	337
	Low	100	130	155	183	212	242
Other boating	High	100	132	164	209	257	315
	Medium	100	119	136	159	182	207
	Low	100	110	110	127	137	147
Swimming outdoors	High	100	124	150	189	229	278
	Medium	100	114	127	146	164	183
	Low	100	106	111	117	125	131
Water skiing	High	100	127	156	204	249	308
	Medium	100	109	117	137	155	175
	Low	100	98	96	96	101	105

Table 3.2 — *Indexes of demand for outdoor recreation in the contiguous States by activity group and type of activity, 1977, with projections to 2030 — continued*
(1977 × 100)

Activity group and type of activity	Projection level[1]	Projections					
		1977	1990	2000	2010	2020	2030
Snow and ice:	High	100	139	179	239	300	377
	Medium	100	123	143	175	207	240
	Low	100	113	124	137	155	170
Cross-country skiing	High	100	154	211	290	376	479
	Medium	100	133	161	200	241	280
	Low	100	118	134	151	172	190
Downhill skiing	High	100	162	227	318	416	538
	Medium	100	142	178	228	279	334
	Low	100	125	146	171	199	226
Ice skating	High	100	137	176	234	293	367
	Medium	100	123	143	174	205	237
	Low	100	113	124	138	155	170
Sledding	High	100	131	165	218	268	334
	Medium	100	117	132	160	187	215
	Low	100	109	116	126	140	154
Snowmobiling	High	100	126	151	191	229	277
	Medium	100	109	120	141	161	181
	Low	100	107	114	122	133	141

[1] Projection levels are keyed to the projections of population, economic activity and income shown in table 1.1.
[2] Index of projected increases in population (medium level).

International Demands

International travel for outdoor recreation continues to expand despite the constraining effects of the world energy shortages and inflationary pressures on disposable income. Historically, the number of U.S. citizens traveling to other nations has far outweighed the number of foreign visitors to the United States. The United States Travel Survey[14] statistics reveal that 133 million foreign trips were made by U.S. citizens for outdoor recreation in 1977. This amounts to 10 percent of all foreign trips made. Over half of the trips by Americans to other countries were to Canada, while another 14 percent were to Mexico. Europe is by far most popular overseas destination, accounting for over 40 percent of the overseas tourists in 1977.

One indication of the outdoor recreational activities which American tourists enjoy in other countries can be found in a study by the Canadian Government Office of Tourism.[15] Its survey of United States automobile visitors found that trips for pleasure were the most popular, and that activities participated in by the largest numbers of visitors included swimming, fishing, hiking, picnicking, motor boating, and canoeing. Most outdoor recreation occurs in the settled southern one-third of Canada, which contains about a million square miles. Land in the northern two-thirds of the country, the majority of which is publicly owned and under Federal or Provincial jurisdiction, is open to outdoor recreational activities, such as fishing and hunting.

Trips for pleasure were also the primary reason that travelers from other countries visited the United States. During the period of 1965-1978, the travel market to the United States grew at an average annual rate of 7 percent in terms of visitor arrivals, and nearly 12 percent in terms of tourist spending. By 1978, the international market reached 19.8 million arrivals and nearly $33 billion in expenditures.[16] About 57 percent of the arrivals in the United States are from Canada, 31 percent from overseas, and 12 percent from Mexico. However, arrivals from overseas contribute 49 percent of the total expenditures here, while Canada contributes 29 percent and Mexico 22 percent.

The designations of many visitors from other countries tend to reflect the point of origin. The Pacific

[14] U.S. Department of Commerce, Bureau of the Census. U.S. travel survey, 1977. Washington, D.C. 1977.

[15] Canadian Government Office of Tourism. Canadian summer travel surveys — 1977 auto exit survey. Ottawa, Ontario, Can. 1977.

[16] Shipka, B. D. International travel to and from the United States. Paper presented at the Travel Outlook Forum, U.S. Travel Service, Research and Analysis Division, Washington, D.C. 1976.

Table 3.3 — *Indexes of demand for outdoor recreation in the contiguous States by activity group and region, in 1977, with projections to 2030*

(1977 × 100)

Activity group and region with percentage of national total	1977	Projections				
		1990	2000	2010	2020	2030
Land:						
Northeast (26)	100	109	118	129	141	152
North Central (27)	100	110	120	133	146	158
Southeast (15)	100	111	124	141	158	171
South Central (11)	100	109	118	131	145	156
Rocky Mountains and Great Plains (7)	100	111	121	132	146	158
Northern Rocky Mountains[1]	100	102	106	112	120	126
Southern Rocky Mountains[2]	100	118	131	146	164	179
Great Plains[3]	100	104	110	119	129	139
Pacific Northwest (3)	100	113	125	139	153	166
Pacific Southwest (11)	100	118	135	155	174	188
All regions (100)	100	111	121	135	149	161
Water:						
Northeast (26)	100	118	134	157	179	205
North Central (28)	100	119	136	161	185	211
Southeast (16)	100	118	135	163	191	218
South Central (11)	100	116	129	152	175	199
Rocky Mountain and Great Plains (6)	100	114	125	142	161	180
Northern Rocky Mountains[1]	100	105	110	120	133	143
Southern Rocky Mountains[2]	100	121	136	158	181	204
Great Plains[3]	100	107	114	128	142	158
Pacific Northwest (3)	100	116	130	150	169	188
Pacific Southwest (10)	100	121	140	167	192	214
All regions (100)	100	118	134	158	181	206
Snow and ice:						
Northeast (32)	100	126	148	180	212	246
North Central (43)	100	123	143	177	211	248
Southeast (5)	100	100	111	134	155	175
South Central (4)	100	98	104	125	142	161
Rocky Mountains and Great Plains (6)	100	123	143	170	200	228
Northern Rocky Mountains[1]	100	113	125	144	164	182
Southern Rocky Mountains[2]	100	131	155	188	224	258
Great Plains[3]	100	115	131	153	177	200
Pacific Northwest (2)	100	123	144	175	207	235
Pacific Southwest (8)	100	126	149	157	225	257
All regions (100)	100	123	143	175	207	240

[1] Northern Rocky Mountains includes the States of Montana, Idaho, and Wyoming.
[2] Southern Rocky Mountains includes the States of Nevada, Utah, Colorado, Arizona, and New Mexico.
[3] Great Plains includes the States of North Dakota, South Dakota, Nebraska, and Kansas.

Coast is the most popular travel destination of any region in the Nation, with many of its international visitors originating in Asia and Oceania. Other popular areas are the Northeast, especially for Europeans, and the Rocky Mountain and Great Plains, which receive more long term visits than other regions. These extended stays suggest that the visitors making them tended to prefer touring and outdoor recreational activities.

In 1976, U.S. Travel Service's Market Survey[17] also reports that most visitors from other countries "saw beautiful scenery," while over a third participated in warm weather sports and 4 percent in winter sports and activities; more specifically, 9 percent went camping, and 3 percent went snow skiing. Initial estimates indicate that international visitors represented about 2 percent of all users of the Nation's outdoor recreational facilities.[18]

Overall, trends in international tourism over the past decade suggest that if the steady expansion of the world economy and repeated improvements in transportation technology continue, the Nation's international travel trade deficit eventually can be reduced. The Nation's balance-of-trade deficit of $30-$40 bil-

[17] *Ibid.*

[18] U.S. Department of Interior, Heritage, Conservation, and Recreation Service. Federal estate outdoor recreation participation survey. (In process).

lion will also have a significant impact on international tourism in the future. It is expected that relative prices in other countries will rise, with an accompanying relative decrease in prices in the United States; as a result, Americans will spend less money traveling abroad and more on vacationing at home, while the opposite will occur in other countries.

Projections by the U.S. Travel Service support this trend: An 8 percent increase in foreign visits to the United States is projected during the next decade, while only a 3 percent increase in U.S. travel to other countries is expected. One result of such a situation would be an increase of about 1 percent in the total demand for recreational opportunities on U.S. forest and range land.

Outdoor Recreation Supply

Forest and range lands provide a broad spectrum of opportunities for recreational experiences. At one end of the continuum is the opportunity for primitive experiences, which require little or no modification of the natural environment. These experiences can be characterized by limited or difficult access, the absence of convenience facilities, low and relatively dispersed use densities, and the absence of on-the-ground controls. At the other end of the spectrum are highly developed opportunities, which are distinguished by easy access, highly developed facilities and user conveniences, high and relatively concentrated use densities, and highly visible visitor controls.[19]

Although nearly all of the Nation's 1.7 billion acres of forest and range lands and the associated waters are capable of supporting some types of outdoor recreation activities, currently only a small proportion of that acreage is being intensively managed for

[19] Brown, P. J., B. L. Driver, and C. McConnell. Opportunity spectrum concept, behavioral information in outdoor recreation resources supply inventory: Background and application. Paper presented at National Workshop of Integrated Inventories of Renewable Natural Resources, Tucson, Ariz., Jan. 8-12, 1978. Also Clark, R. N. and G. H. Stankey. The outdoor recreation opportunity spectrum: A framework for management planning and research. U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest Exp. Sta., Portland, Ore. (In process).

Scenic beauty attracts many visitors to the U.S. from other countries. The lake, Spirit Lake, and forest in this picture were ravaged by an eruption of Mount St. Helens (in the background) in May 1980.

recreational purposes. Limited use areas, such as parks and reservoirs, and developed recreational sites, such as campgrounds and picnic areas, account for a high proportion of this acreage.

Private outdoor recreation supply. —The 740 million acres of private forest and range lands in the United States represent a substantial land base for outdoor recreation, especially in the eastern United States. Of the 672 million acres of private, noncorporate forest and range lands in the United States, about 50 percent is located in the eastern United States. Also, over half of the Nation's 68 million acres or corporate forest and range lands are in the South with 19 percent in the populated Northeast.[20]

In providing a wide variety of outdoor recreational opportunities, the private sector has assumed an expanding role as a supplier in recent years. In the public sector, where sentiment is more and more one of leaving the development of capital-intensive, convenience-oriented facilities to the private sector, trends reflect a growing recognition of the complementary nature of public and private supplies of outdoor recreation.

Presently, the majority of the developed ski areas, campgrounds, marinas, swimming pools, and guest houses and ranches are on private lands. In addition, private lands constitute a sizable recreation resource for such dispersed opportunities as hunting, fishing, hiking, picnicking, horseback riding, and off-road vehicle use. Currently, about 29 percent of the private, noncorporate and 54 percent of the corporate forest and range lands in the United States, are open to the public for some form of recreation (table 3.4).[21] Further, an additional 50 percent of noncorporate and 15 percent of corporate lands are currently available either to family members, friends, and employees of the owners, or to special groups through lease or other arrangements. Although unavailable to the general public, considerable recreational use is made of these lands by the owners and their guests. For example, 64 percent of owners allow guests to hunt on their property.

The availability of land to the general public for outdoor recreation varies considerably among regions. For example, the percentage of corporate land available for public use varies from a high of 67 percent in the Pacific Southwest and 63 percent in the North Central region, to a low of 49 percent in the Pacific Northwest and 51 percent in the Northwest. The percentage of private noncorporate land available varies from highs of 44 percent in the Rocky Mountain and Great Plains and 42 percent in the Northeast, to lows of 16 percent in the South Central States and less than 10 percent in the Southeast. The high percentage in the Northeast is heavily influenced by the land available in Maine where, traditionally, much of the private land is open for public use.[22]

Noncorporate and corporate owners have several reasons for their particular public use policies. Improved public relations, or some other form of a "good neighbor" policy, is the primary motivation of 41 percent of noncorporate and 63 percent of corporate landowners to open lands (fig. 3.2).

An additional 8 percent of noncorporate and 3 percent of corporate owners cited income earning potential. Twenty-one and 13 percent, respectively, indicated that their land is open because it would be too difficult and costly to post and enforce the postings. Another reason for opening significant acreages of corporate land for public use is multiple-use management.

Hunting is by far the most common recreation use allowed by both noncorporate and corporate landowners. Sixty-three percent of noncorporate landowners permit hunting on the lands they have designated as generally open to public use. Similarly, 84 percent of corporate owners permit hunting. Hiking and fishing also are commonly permitted activities with 37 percent of the noncorporate owners permitting these activities; for corporate owners, 70 percent permit hiking and 63 percent permit fishing. Activities such as picnicking, camping, horseback riding, and off-road vehicular use are also commonly allowed. Other activities, such as snow skiing, boating, and swimming are permitted, but by many fewer owners, perhaps due to a lack of suitable climate or facilities.

Future prospects for increasing the availability of developed private lands for such recreational uses as campgrounds, ski developments, and marinas are encouraging where returns on investments may be

[20] Corporate forest and range lands include holdings by business (mostly manufacturers, but including other commercial enterprises) as opposed to private, noncorporate holding where objectives of ownership are usually personal.

[21] Cordell, H. K., R. McLellan, H. Stevens, G. Tyre, and M. Legg. Existing and potential recreation role of privately owned forest and range lands in the United States: An assessment. (In process). (Information describing private lands and their recreational potential as described in this section was derived through a nationwide survey during 1977 and 1978 of private, corporate, and government landowners and managers. This study was a cooperative effort among the Forest Service and Soil Conservation Service of the U.S. Department of Agriculture, Clemson University, Stephen F. Austin State University, and the University of Kentucky. Detailed data from the study will be published as technical reports in the near future by the Southeastern Forest Experiment Station).

[22] Steward, B. E. Recreation use of private land in a portion eastern Maine. Maine Agricultural Experiment Station, Misc. Pub. 685. 1963.

Table 3.4 — *Percent of private forest and range land in the United States available for public recreation use by availability status, ownership, and region, 1977*
(Percent)

Availability status	Ownership status	Region							
		Total U.S.	North-east	North Central	South-east	South Central	Rocky Mountains and Great Plains	Pacific Southwest	Pacific Northwest
Open to public without permission	Noncorporate[1]	6	15	1	4	4	10	1	4
	Corporate[1]	42	50	62	29	42	52	45	43
Open only with fee, permit, or verbal permission	Noncorporate[1]	23	27	20	9	12	34	20	24
	Corporate[1]	12	1	1	25	11	4	22	6
Closed except for owner, special group or employee use	Noncorporate[1]	50	31	45	36	70	37	33	37
	Corporate[1]	15	1	1	16	24	21	10	10
Not designated	Noncorporate[1]	21	27	34	35	14	19	46	25
	Corporate[1]	31	48	36	30	23	47	23	41

[1]Corporate forest and range lands include holdings by business (mostly manufacturers but including other commercial enterprises as opposed to private, noncorporate forest and range lands which includes individual, family, or partnership ownership where the objectives for ownership are usually personal).

Source: Cordell, H. Ken, Robert McLellan, Herbert Stevens, Gary Tyre, and Michael Legg. *Existing and potential recreation role of privately owned forest and range lands in the United States:* An assessment. (In process).

satisfactory. However, prospects are not promising for activities which offer little or no economic return. For instance, current percentages of noncorporate lands being put to recreational use indicate a significant drop in availability when compared with earlier studies. Brown reported a 68 percent increase in land posting in New York between 1963 and 1972.[23]

The major reasons for closing lands include interference with other activities, property damage, disturbance of privacy, and wildlife disturbance. Also, many landowners who have land open for public use feel that recreational visitors create problems such as littering, fire, illegal hunting, vandalism, crop damage, and theft. In most of these situations, the landowners are protected by laws which prohibit such acts as fire setting and vandalism. Apparently, however, landowners do not feel that existing levels of law enforcement are adequate to fully protect their rights and property, and future closure of their lands is a possibility.

An underlying cause of the lack of management programs for recreation is that most private landowners have objectives or primary uses for their lands other than recreation. In fact, recreation is seldom a major land-management objective for private lands. Only 3.7 percent of the corporate land managers and 1 percent of the noncorporate owners have commercial recreation as a primary management objective for their forest and range lands. Other land uses which take precedence over recreation include timber or pulpwood production, livestock grazing, agriculture production, and residential developments. It would appear that, if problems with recreational use of private lands could be reduced, more private lands would be available to the general public; this would reduce the pressure for increased government acquisition, development, and operation of recreation lands.

Public outdoor recreation supply — Federal forest and range lands in the United States represent a substantial land base for outdoor recreation with the Federal Government owning 718 million acres or nearly 46 percent of the total United States forest and range land acreage. Although more than 100 agencies, boards, and commissions have an influence on recreational supply, seven Forest agencies provided most of the outdoor recreational opportunities on those lands in 1977. The Forest Service supplied the largest number in terms of visitor days of recreation, followed by the Corps of Engineers, National Park Service, and Bureau of Land Management (table 3.5, fig. 3.3). Together these agencies managed lands

[23] Brown, T. L. and D. Q. Thompson. Changes in posting and landowners attitudes in New York State, 1963-1973. New York Fish and Game Journal 23 (2): 101-137. 1976.

Timberline Lodge on Mt. Hood, constructed by the Federal Government in the 1930's. Now the construction and operation of such capital-intensive, convenience-oriented outdoor recreation facilities are almost entirely in the private sector.

Figure 3.2

Reasons Given by Landowners for Allowing Public Use of Their Land

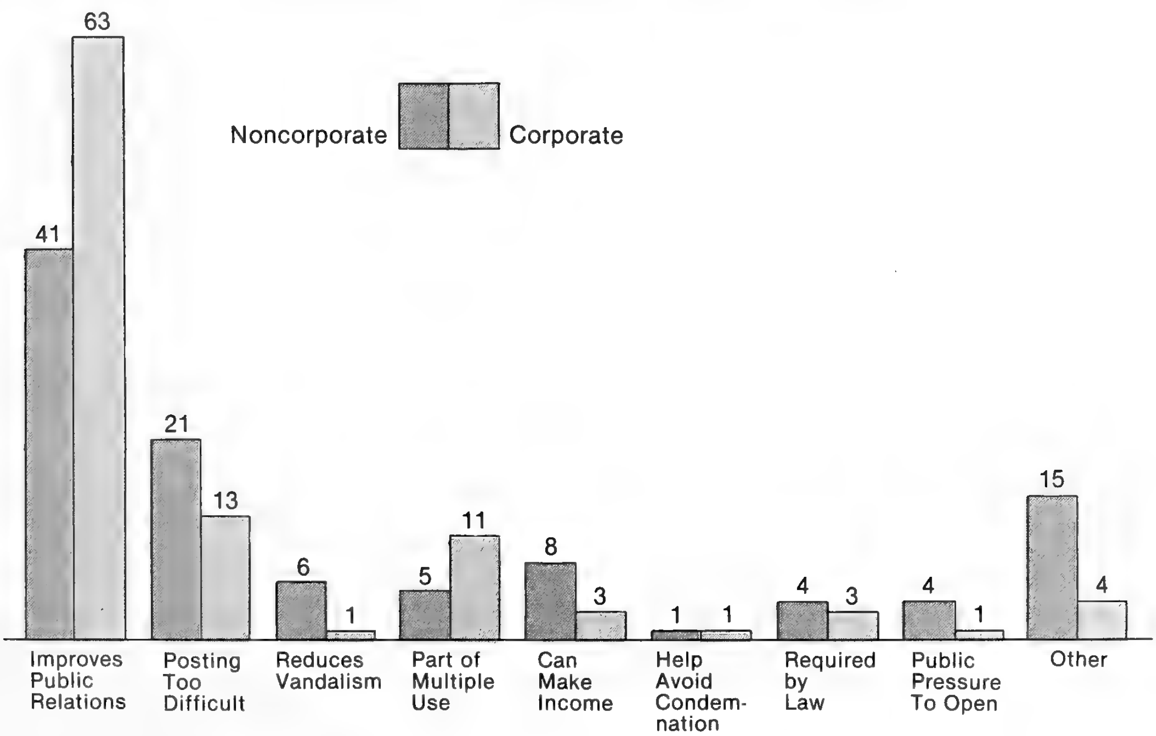
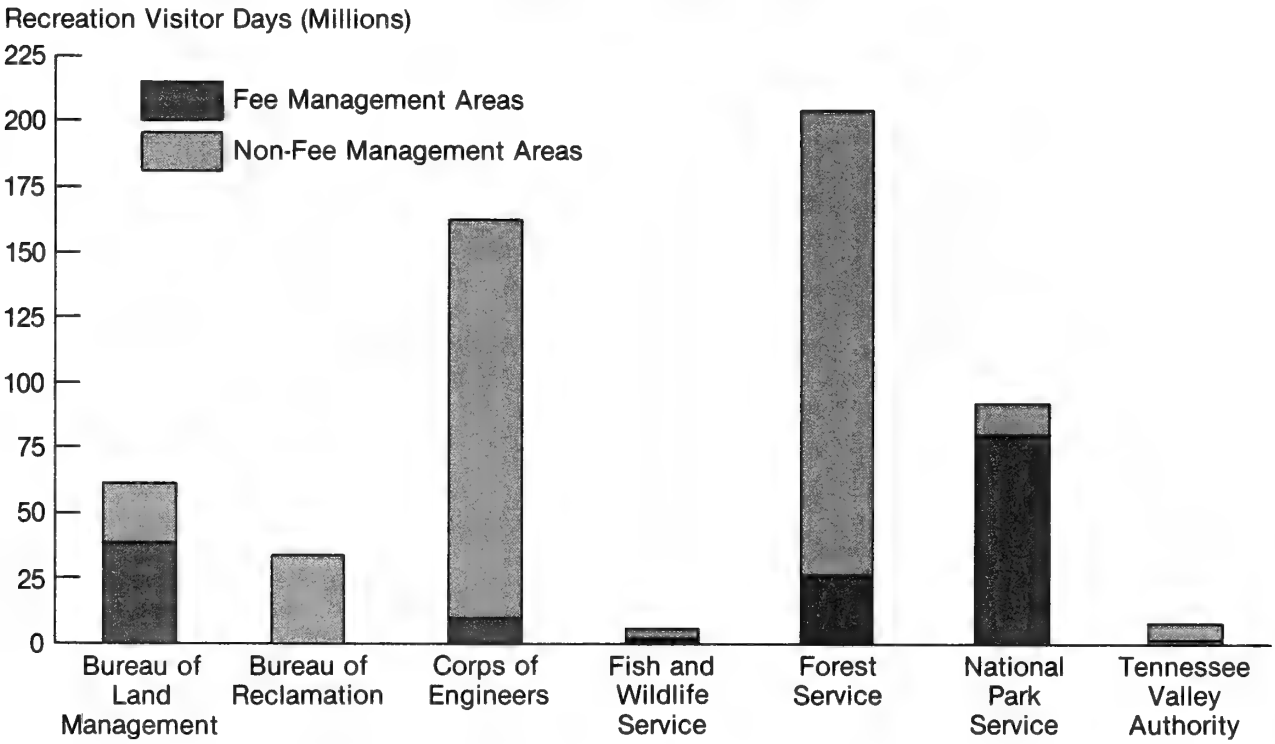


Figure 3.3

Recreation Visitor-Days of Use Provided at Federal Areas



supporting over 90 percent of the recreational use on the Federal estate. Other Federal agencies supplying significant recreational opportunities included the Bureau of Reclamation, Fish and Wildlife Service, and Tennessee Valley Authority.

The prevalent type of recreational experience provided differs markedly among the various Federal agencies. Most recreational visits to National Park and Corps of Engineers lands occur in areas with well-developed facilities such as visitor centers, marinas, campgrounds, and picnic areas. On lands administered by the Forest Service and the Bureau of Land Management, a majority of the recreational use occurs in dispersed areas where the most popular activities pursued are primitive camping, summer and winter recreation travel, hunting, and fishing.

The types of experiences sought by recreationists on Federal lands also appear to differ significantly according to the results of an on-site survey which was part of the 1977 National Outdoor Recreation Survey.[24] Interviews with 11,549 recreationists indicated that the main attraction of Corps of Engineers areas was their "good" facilities, while scenic beauty was most important to National Forest visitors. The desire to see a new area was expressed as the most frequent reason individuals visited National Parks. This survey also showed that the Forest Service provided the greatest number of long term recreational experiences on Federal lands. Over 50 percent of the Forest Service visitors stayed more than 2 days during their visits, while another 20 percent spent at least 7 days.

Differences in recreational opportunities on Federal lands reflect the management directions of the administering agencies and the resources available for use. One major class of Federal areas is comprised of those units administered by the National Park Service, which oversees the best-known and most distinctive recreation resources in the United States. In 1977, there were 34 National Parks containing some of the most outstanding scenic areas in the world. In addition, there are a large number of other units such as battlefields, seashores, and historic sites. Overall, the National Park Service administers nearly 300 areas covering some 31 million acres in 49 States, the

[24] U.S. Department of Interior, Heritage, Conservation and Recreation Service. Federal estate outdoor recreation participation survey. (In process).

Table 3.5 — *Recreation visitor days[1] of use of federal recreation areas in the United States by managing agency and fee status, 1977*

Agency	Total		Fee management units		Nonfee management units	
	Thousands	*Percent*	*Thousands*	*Percent*	*Thousands*	*Percent*
Bureau of Land Management[2]	60,225	10.6	39,915	7.0	20,310	3.6
Bureau of Reclamation	33,607	5.9	146	.0	33,461	5.9
Corps of Engineers	162,751	28.8	10,238	2.0	151,513	26.8
Fish and Wildlife Service	6,010	1.1	1,123	.2	4,887	.9
Forest Service	204,797	36.1	25,646	4.5	179,151	31.6
National Park Service	92,029	16.3	79,596	14.1	12,433	2.2
Tennessee Valley Authority	6,980	1.2	542	.1	6,438	1.1
Total	566,399	100.0	158,206	27.9	408,193	72.1

[1]Recreation use which aggregates 12 person hours may entail 1 person for 12 hours, 12 persons for only 1 hour, or any equivalent combination of individual or group use.
[2]A Federal fee area provides certain specialized outdoor recreation facilities, equipment, or services at Federal expense and then charges fees — entrance, user, and/or special permit — to cover costs. The Bureau of Land Management is the only Federal agency which includes areas charging special permit fees under this category.
Source: U.S. Department of Interior, Heritage Conservation and Recreation Service. *Federal recreation fees-1977.* (In process).

District of Columbia, Puerto Rico, and the Virgin Islands.

The fundamental purpose for which the National Park System was established was stated in the Act of 1916 creating the National Park Service: ". . . to conserve the scenery and natural and historic objects and wildlife therein; and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The National Park Service has attempted to adhere to this policy over the years, but has experienced increasing difficulty as use pressure has mounted. While fulfilling an important role in providing outdoor recreation, their lands must serve varied preservation, scientific, educational, and cultural purposes. For instance, recreational facilities in National Parks are designed to protect the unique qualities of each area. Often, this means restricting concentrations of people to developed areas such as campgrounds and visitor centers, channeling visitors' movements with hardened foot paths, and restricting backcountry travel to well-marked areas. The recreational activities allowed are also limited. As an example, hunting is forbidden in most National Parks.

A second major class of Federal areas important for outdoor recreation is "water" areas. The Bureau of Reclamation, the Corps of Engineers, and the Tennessee Valley Authority are all Federal agencies which administer reservoirs, other impounded waters, rivers, and the land surrounding them. While serving such primary purposes as flood control, irrigation, and hydroelectric power generation, the projects administered by these agencies also provide significant water recreation opportunities. These include swimming, boating, water skiing, picnicking, camping, fishing, and sightseeing. Together, these agencies have constructed over 750 reservoirs with 7.7 million surface acres of water and 69,000 miles of shoreline.

A third distinctive type of Federal area includes all units administered by the Forest Service and the Bureau of Land Management. Together, these agencies administer 93 percent of the forest and range land in Federal ownership and provide significant dispersed recreational opportunities. For instance, dispersed recreation accounts for two-thirds of the participation on the National Forests (table 3.6).

Although the official policy of the Forest Service and Bureau of Land Management has been to encourage outdoor recreation, most of these lands are managed to ensure the continuous provision of all forest and range products, including timber, water, grazing, and wildlife. Consequently, as with all other resource opportunities, the recreational opportunities offered to the public must be compatible with the overall objectives established for each area. Also, the type of recreational opportunities provided is often influenced by management activities for other forest uses or products. For instance, roads built principally for timber harvest also provide opportunities for dispersed camping with motorized vehicles and can serve as cross-country ski and snowmobile trails when snow-covered.

Special designation of Federal lands also influences the recreational opportunities they provide. One type of specially designated Federal lands is the National

Table 3.6—*Number of recreation visitor days of outdoor recreation activities on National Forests in the United States by types of activity and area, 1978*

(Thousands)

Activity group and type of activity	Total	Developed	Dispersed
Land:			
Bicycling	434.2	11.5	422.7
Camping	59,902.6	41,539.8	18,362.8
Motor bike	4,520.7	2.8	4,517.9
Hiking[1]	10,925.6	196.8	10,728.8
Horseback riding	3,038.3	31.5	3,006.8
Hunting	14,946.2	13.9	14,932.3
Nature study	1,257.3	205.9	1,051.4
Picnicking	8,762.8	6,094.1	2,668.7
Pleasure walks	1,587.0	132.8	1,454.2
Sightseeing[2]	52,387.5	4,851.3	47,536.2
Other[3]	16,028.0	12,395.9	3,632.1
	173,790.2	65,476.3	108,313.9
Water:			
Canoeing	1,099.7	209.6	890.1
Sailing	261.1	76.1	185.0
Other watercraft[4]	6,286.7	1,416.3	4,870.4
Fishing	16,559.1	581.2	15,977.9
Swimming	4,441.8	1,790.1	2,651.7
Water skiing	983.0	65.4	917.6
	29,631.4	4,138.7	25,492.7
Snow and Ice:			
Cross-country skiing	760.5	——	760.5
Downhill skiing	9,335.7	9,335.7	——
Ice skating	67.8	27.8	40.0
Sledding	107.9	107.5	.4
Ice and snowcraft	3,439.0	118.2	3,320.8
Snowplay	1,361.8	426.3	935.5
	15,072.7	10,015.5	5,057.2
Grand Total	218,494.3	79,630.5	138,863.8

[1] Includes mountain climbing.

[2] Includes viewing outstanding scenery, auto driving, aerial trams and lifts, viewing works of man, and VIS related.

[3] Includes spectator sports and activities, team sports, games, other accommodations, gathering forest products, and acquiring general knowledge and understanding.

[4] Includes ship, yacht, ferry, and powered boats.

Recreation Area. With primary management direction in National Recreation Areas centering on outdoor recreational opportunities, management of such other resources as timber, range, and minerals may be secondary, depending upon the use restrictions imposed by the administering agency. The concept of these areas has grown to encompass a wide variety of lands and waters set aside by Congress for recreational use, especially around major urban areas. The acreage of these lands has grown from 116,000 acres in 1962 to more than 3 million acres by 1977. Presently, 17 National Recreation Areas are administered by the Park Service and seven by the Forest Service.

Other systems established by Congress to promote, preserve, and protect recreation and other resources across the Nation include the National Wilderness Preservation System, the National Wild and Scenic Rivers System, and the National Trails System. These systems will be discussed later.

Many of the problems associated with providing outdoor recreation opportunities on public lands arise from the uneven geographic distribution of Federal lands. Although Federal units are represented throughout the United States, over 90 percent of the forest and range lands in Federal ownership are located in the western United States, including Alaska. This means that for every individual living in the western United States, there are 16 Federal forest acres. In contrast, the northern States have 1.9 percent of the Federal forest and range land or 0.1 acre per person, and the southern States have 2.4 percent or 0.3 acre per person.

To some degree, Federal agencies can offset regional acreage limitations by expending more funds and committing available acres to outdoor recreation. However, it appears that even these actions currently reflect geographic differences. For instance, there are 16 National Recreation Areas located in the western United States, while there are only four in the southeast and four in the Northeast. Similarly, the distribution of expenditures for outdoor recreation by Federal Government agencies on a per capita basis is largest in the western regions (fig. 3.4).

The geographic balance of public lands is more evenly distributed, however, if the 6 percent of the forest and range lands owned by State and local governments is also considered. Although States own only 1.6 million acres in the southeastern and 3.3 million acres in the South Central regions, States in the Northeastern region own 9.6 million acres and those in the North Central region own 11.8 million. Noteworthy examples of State-owned tracts are the Adirondack (2.5 million acres) and Catskill (259,000 acres) State Parks in New York, and Baxter State Park (200,000 acres) in Maine. The addition of State lands more than doubles the per capita availability of public forest and range lands in the North to 0.3 acre per person.

State and local lands thus constitute an important supply of outdoor recreational opportunities which can complement those provided on Federal areas. Many State parks, forests, and wildlife areas possess significant scenic, historical, cultural, and other recreational features. Others provide outdoor recreational opportunities to metropolitan centers. States reported that their parks had more than 565 million

Recreation can be compatible with other forest management objectives. Logging roads can serve as cross country ski trails in winter and hiking trails in summer.

visits in 1975, which represented an increase of 45 percent in the number of visits over those made in 1967.[26]

Nonetheless, it is difficult to fully assess the national impact of State and locally owned units on outdoor recreation. There are few common denominators between States and local governments with respect to the administration of lands. Some States manage their land strictly according to use designation — like those State Parks managed solely for outdoor recreation and preservation of resources. In other States, State Parks and State forests are managed for both recreational purposes and other forest and range products without special distinction between the two systems. Also, some States have not yet given their lands any special classification. An example is Alaska, which, as a result of the Statehood Act, has 36.4 million acres in State ownership, but presently lacks any special management classification of its land. Similarly, several western States have school trust lands. Some of these tracts are administered by agencies, like public school systems, whose primary responsibility is not land or recreation management.

[26] The National Association of State Park Directors and Missouri Division of Parks and Recreation. State park statistics — 1975. National Recreation and Park Association, Arlington, Va. 34 p. 1977.

Future prospects for increasing the availability of outdoor recreational opportunities on public lands will depend on two factors: (1) The continued recognition of outdoor recreation values to society and (2) a continuing commitment to the funding necessary for the expansion and maintenance of outdoor recreational resources. While fulfilling an important role in supplying recreational opportunities, most public lands must also serve other purposes. These include such diverse purposes as generation of hydroelectric power, timber production, fish and wildlife habitat, preservation of wilderness, municipal watersheds, a source of minerals, and livestock production. In planning future programs for public lands, outdoor recreation must be given adequate consideration with other objectives for public lands if future generations are to enjoy outdoor recreational experiences equal to what the Nation has come to appreciate.

Equally important will be the need for adequate funding in the future. Expenditures by the Federal Government in outdoor recreation totalled $1.5 billion in 1975, an increase of 91 percent over the 1965 level.[27] Due to inflation, however, this rise represented only a slight increase in real value and may

[27] Federal outdoor recreation expenditure study, 1975, *op. cit.*

actually have reflected a decrease in Federal commitment given the broadened coverage of the more recent compilations. At the same time, there was an increasing emphasis being placed on the maintenance and rehabilitation of existing facilities rather than developing new ones. Appropriations for outdoor recreation larger than those presently allocated are needed if public recreational opportunities are to be sufficiently expanded to meet the demand created by increasing public participation.

Supply and Demand Comparisons

Because of the lack of data, it was not possible to adequately prepare longrun projections of supplies for the various outdoor recreational activities. However, the projected increases in demand (table 3.2) indicate how much supplies might have to be increased if demands are to be met. In addition, regional demand increased in each region of the country. The national and regional needs for increases in supplies, as shown by the demand projections, are supplemented in the following discussion:

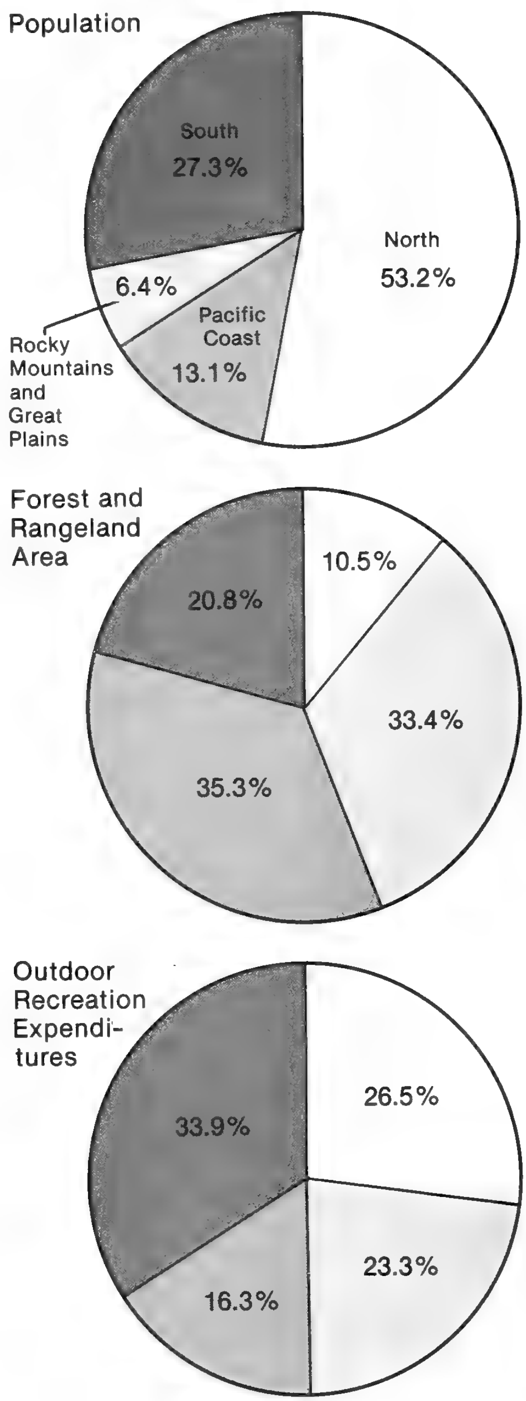
Dispersed land activities — Recent increases in participation of dispersed land activities have been substantial. In 1978, for example, over half of the recreational use of National Forest lands was for dispersed land activities, amounting to over 108 million recreation visitor days of use. That figure represents an increase of approximately 35 million recreation visitor days over the last decade.

Increased participation in dispersed land recreation can be attributed to a number of factors. Over a decade ago, the back-to-nature movement and mounting interest in physical fitness and outdoor activity together spawned the resurgence of hiking, backpacking, mountain climbing, and similar activities. The availability of recreational vehicles, both for camping and off-road driving, has also added a completely new dimension to dispersed land recreation. Camping along roadsides has increased with the growing popularity of recreation vehicles such as truck campers, camping and travel trailers, and motor homes. And the development of lightweight, dependable, and high-performance off-road vehicles (motorcycles, all-terrain vehicles, and four-wheel drive vehicles) and the extension of forest roads has established motorized travel as a popular activity on forest and range lands.

The very freedom and lack of development which characterize dispersed land activities make any precise statement about the current supply situation for these opportunities difficult. Nonetheless, it appears that the potential supply of dispersed land opportunities — both nonmotorized and motorized — is considerable.

Figure 3.4

Comparison of Population, Forest and Rangeland Area and Outdoor Recreation Expenditures by Geographic Area



For nonmotorized activities, many of the public lands are available as well as about a third of private forest and range lands in the United States. However, the provision of trails is important for the enjoyment of nonmotorized recreational activities. Originally established as travel routes by Indians and early settlers, trail networks were improved and augmented by early land managers to help protect and manage forest and range resources. Because trails have only recently assumed their primary value as recreational resources, most trails were designed for other uses. Also, many trails have been replaced by roads. As one result, the 150,000 miles of trails existing on National Forest lands in 1944 have been reduced by 93,000 miles (table 3.7). Currently, trails on all Federal lands total over 109,000 miles, while more than 36,000 miles of trail are under State ownership, and 116,000 miles are on private land. The estimated cost of construction for Forest Service trails presently averages about $10,000 per mile. Maintenance costs run about $130 per mile per year.

Congressional recognition of the importance of recreational trails resulted in the passage of the National Trails System Act in 1968. An important step in ensuring the development and maintenance of the country's supply of trails, the Act called for designation of National Trails, and connecting and side trails. Thus far, three scenic trails have been established — the Appalachian Trail (2,050 miles), Continental Divide Trail (3,100 miles), and the Pacific Crest Trail (2,460 miles) — and four historic trails — Oregon Trail, Lewis and Clark Trail, Mormon Trail, and Iditarod Trail (Gold Rush Trail). Another 10 trails are either under study or have yet to be acted upon by Congress (fig. 3.5).

Numerous opportunities for dispersed motorized activities exist on the Nation's forest and range lands. For example, nearly 247,000 miles of Forest Service roads provide a substantial opportunity base. These roads include just over 10,000 miles of paved roads, over 55,000 of rock and graveled roads, and over 99,000 miles of primitive condition roads. Informal dispersed recreational sites located along these roads, such as clearings resulting from timber harvest, provide a large number of opportunities for activities including roadside camping and motorcycling.

One indication of the quantity of such sites now in use can be found in a study of dispersed road recreation on three National Forests in the Pacific Northwest.[28] This study identified 622 sites, which if defined as specific locations showing evidence of camping or other recreational activity, along 316 miles of road. From 10 to 17 percent of these sites had experienced a heavy degree of environmental impact from use and appeared to be among the most popular with users.

In addition to existing roads, many trails and open areas on public lands are available for off-road vehicle use, although restrictions on certain vehicles and seasons of use have been placed on 41 million acres. Additional lands could be made available if areas being considered for wilderness designations are opened to nonwilderness uses.

Regulations on off-road vehicle use are being developed by the Bureau of Land Management. They may result in a moderate reduction in the supply of off-road vehicle opportunities. For example, 12 million acres of the Bureau's land in California Deserts Conservation Area have already been classified to protect endangered species and areas of high scientific value. Five percent of this land has been completely closed to off-road vehicles, 5 percent is open to all off-road vehicle travel, while 90 percent has been left open, but with travel restricted to particular seasons and existing roads and trails.

Complementing the use of Federal lands as a supply of dispersed recreational opportunities are State, local, and private lands. Private lands constitute a particularly important supply of dispersed motorized activities, especially in the East. Whereas, off-road motorcyclists in the western United States rely equally on National Forest, Bureau of Land Management, and private lands, eastern riders rely very heavily on private lands. In Michigan, for example, the largest proportion of trail biking — 59 percent — occurs on private land, according to a survey conducted by the Michigan Department of Natural Resources in 1976.[29] Although the informality of the use of private lands makes any estimation of their supply difficult, the extent of these lands and their dispersed recreation potential are considerable.

As the popularity of dispersed land recreation has continued to grow, so have the problems associated with dispersed land activities. Environmental problems have intensified with continuing increases in recreation users. Soil and vegetation disruption by foot, horse, and vehicular traffic is destroying the environmental integrity of some areas. Soil compaction has resulted at most heavily used campsites, leaving them barren of vegetation and often either dusty or muddy. Trails are threatened by erosion, which

[28] Hendee, J. C., M. L. Hogans, and R. Koch. Dispersed recreation on three forest road systems in Washington and Oregon: First-year data. U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station, PNW Publication No. 280. 20 p. 1976.

[29] Michigan Department of Natural Resources. Analysis of recreation participation and public opinions on off-road vehicles from a 1976 telephone survey. Recreation Planning and Research Service Section, Recreation Survey Report No. 1. Lansing, Mich. 1977.

Table 3.7—*Trail mileage in the United States and territories, by ownership, and section, region, State and territory, 1978*[1]

Section, region and State	Total	Ownership								
		Federal								
		Total Federal	Forest Service	National Park Service	Bureau of Land Management	Corps of Engineers	Other[2]	State	County and Municipal	Private
North:										
Northeast:										
Connecticut	908	31	0	0	0	31	0	378	10	489
Delaware	395	0	0	0	0	0	0	300	17	78
Maine	5,685	127	80	47	0	0	0	20	88	5,450
Maryland	692	0	0	0	0	0	0	20	0	672
Massachusetts	7,180	93	0	0	0	93	0	1,457	0	5,630
New Hampshire	1,819	1,121	1,055	0	0	66	0	218	0	480
New Jersey	4,235	0	0	0	0	0	0	1,044	606	2,585
New York	4,558	84	22	0	0	62	0	2,220	696	1,558
Pennsylvania	10,856	215	142	0	0	73	0	5,080	1,092	4,469
Rhode Island	497	0	0	0	0	0	0	151	45	301
Vermont	21,614	424	353	0	0	71	0	287	0	20,903
West Virginia	2,315	790	772	0	0	18	0	434	95	996
Total	60,754	2,885	2,424	47	0	414	0	11,609	2,649	43,611
North Central:										
Illinois	4,252	256	195	0	0	61	0	1,015	1,563	1,418
Indiana	3,640	81	47	0	0	24	0	1,590	788	1,181
Iowa	1,241	32	0	0	0	32	0	222	347	640
Michigan	8,940	636	680	6	0	0	0	5,055	100	3,099
Minnesota	3,912	588	581	0	0	7	0	864	0	2,460
Missouri	1,732	277	245	0	0	29	3	357	0	1,098
Ohio	7,456	126	42	0	0	84	0	2,749	0	4,581
Wisconsin	5,368	182	181	0	0	1	0	876	2,712	1,598
Total	36,541	2,228	1,081	6	0	238	3	12,728	5,510	16,075
Total, North	97,295	5,113	4,405	53	0	652	3	24,337	8,159	59,686
South:										
Southeast:										
Florida	1,880	215	169	46	0	0	0	193	621	851
Georgia	2,405	283	283	0	0	0	0	511	290	1,321
North Carolina	4,215	1,271	1,013	258	0	0	0	110	177	2,657
South Carolina	1,405	234	234	0	0	0	0	205	0	966
Virginia	5,367	2,021	1,778	230	0	13	0	856	479	2,011
Total	15,272	4,024	3,477	534	0	13	0	1,875	1,567	7,806
South Central:										
Alabama	787	107	34	0	0	56	17	171	83	426
Arkansas	928	278	222	34	0	22	0	76	75	499
Kentucky	3,525	205	140	8	0	57	0	1,640	991	689
Louisiana	502	179	25	0	0	0	154	2	43	278
Mississippi	471	53	34	0	0	18	1	210	0	208
Oklahoma	471	45	0	0	0	45	0	86	11	329
Tennessee	3,615	850	553	259	0	37	1	389	289	2,087
Texas	493	290	164	68	0	13	45	94	109	—
Total	10,792	2,007	1,172	369	0	248	218	2,668	1,601	4,516
Total, South	20,064	6,031	4,649	903	0	261	218	4,543	3,168	12,322

Table 3.7 — *Trail mileage in the United States and territories, by ownership, and section, region, State and territory, 1978[1] — continued*

Section, region and State	Total	Ownership								
		Federal								
		Total Federal	Forest Service	National Park Service	Bureau of Land Management	Corps of Engineers	Other[2]	State	County and Municipal	Private
Rocky Mountains and Great Plains:										
Arizona	4,932	3,610	3,338	135	136	0	1	0	0	1,322
Colorado	14,886	8,153	7,609	362	179	3	0	600	62	6,071
Idaho	18,215	17,509	17,384	0	123	2	0	137	0	569
Kansas	794	4	0	0	0	4	0	40	70	680
Montana	18,635	14,608	13,552	869	187	0	0	7	32	3,988
Nebraska	12,393	63	63	0	0	0	0	20	5	12,305
Nevada	2,242	2,136	1,756	0	380	0	0	40	2	64
New Mexico	3,535	3,244	3,002	0	242	0	0	37	0	254
North Dakota	634	138	15	110	0	0	13	292	62	142
South Dakota	1,044	351	338	0	0	0	13	140	35	518
Utah	11,816	6,084	5,722	88	274	0	0	1,515	3,646	571
Wyoming	5,797	4,219	2,262	1,217	740	0	0	110	15	1,453
Total	94,923	60,119	55,041	2,781	2,261	9	27	2,938	3,929	27,937
Pacific Northwest:										
Alaska	5,304	3,588	564	24	3,000	0	0	525	102	1,089
Oregon	8,258	7,292	7,181	46	59	6	0	238	136	592
Washington	14,355	7,799	6,749	1,045	0	5	0	1,179	662	4,715
Total	27,917	18,679	14,494	1,115	3,059	11	0	1,942	900	6,396
Pacific Southwest:										
California	33,995	19,758	15,044	3,764	48	0	902	2,173	2,501	9,563
Hawaii	864	269	0	269	0	0	0	415	0	180
Total	34,859	20,027	15,044	4,033	48	0	902	2,588	2,501	9,743
Total, Pacific Coast	62,776	38,706	29,538	5,148	3,107	11	902	4,530	3,401	16,139
Total, United States	281,058	109,969	93,633	8,885	5,368	933	1,150	36,348	18,657	116,084
Virgin Islands	15	8	0	8	0	0	0	0	0	7
Puerto Rico	59	4	4	0	0	0	0	0	0	55
Total	74	12	4	8	0	0	0	0	0	62

[1]Does not include additional snow-covered roads or routes such as snowmobile and cross-country ski trails.
[2]The category "other" consists of the Fish and Wildlife Service and the Tennessee Valley Authority.

Source: U.S. Department of Interior, National Park Service, *National Park trails, Part 1, Special Report.* Service Center 86 p. 1973; National Association of Conservation Districts, *Inventory of private recreation facilities-1977.*

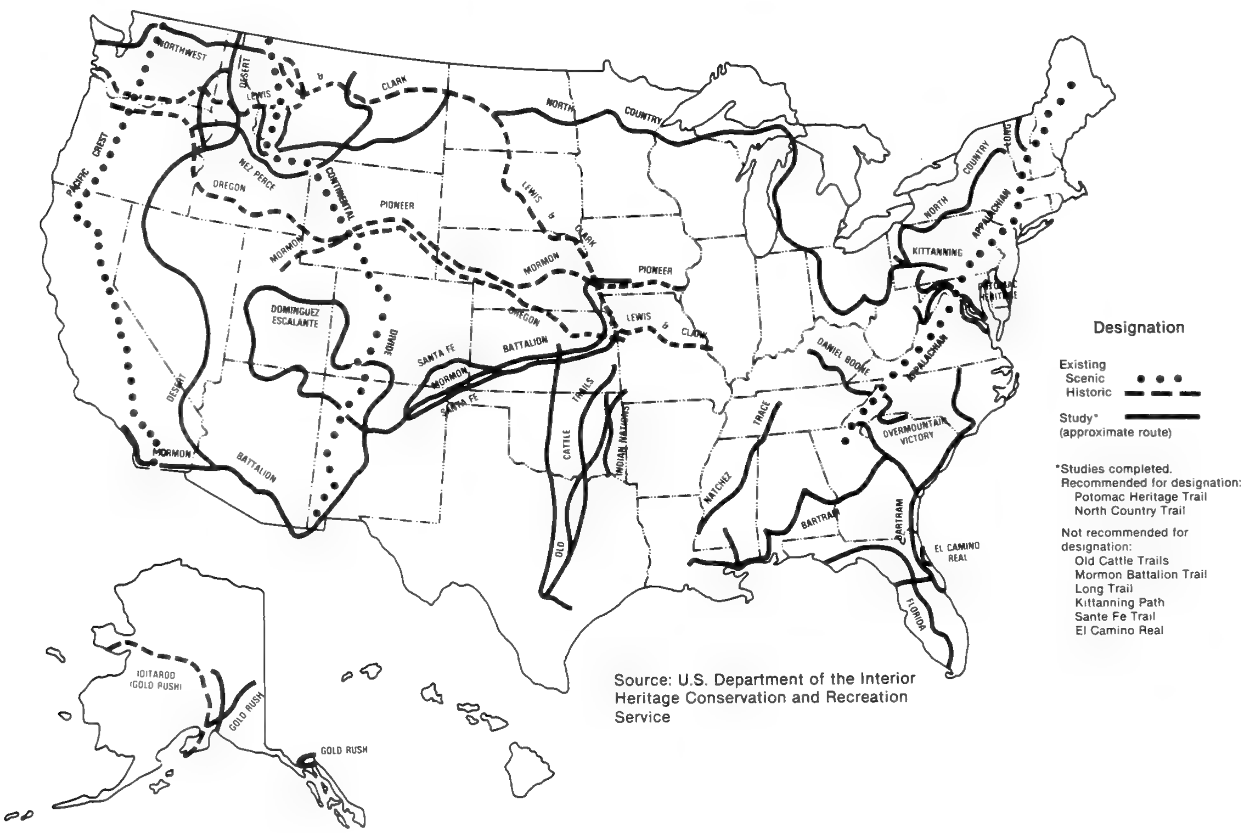
not only scars the land, but also pollutes water and impairs fisheries and aquatic wildlife. Desert lands and alpine tundra are especially fragile environments where resource damage can require decades of natural repair.

Off-road vehicle use has intensified the recreational pressures on public land and has resulted in additional problems such as air, noise, and esthetic pollution. Noise pollution, in particular, may disrupt wildlife. It can also reduce the quality of the esthetic environment, detracting from the enjoyment of some recreational users who desire a quieter, more peaceful experience.

Crowding can be a significant social problem at those times when users experience higher densities of use than they desire. Often, it is not only the number of other recreationists encountered that decreases the users' satisfaction with their experiences, but also the type of use. Conflicts can arise between hikers and horseback riders and between these users and vehicle drivers. Other social problems, such as littering, vandalism, and even theft, have resulted from greater participation in dispersed land activities. And problems of public health and sanitation, including human injury and improper waste disposal, have also increased.

Figure 3.5

National Trails System, National Scenic and National Historic Trails, September 1, 1979



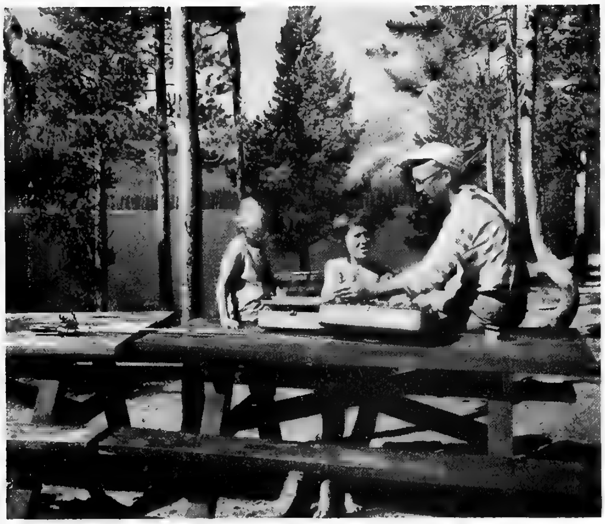
Source: U.S. Department of the Interior Heritage Conservation and Recreation Service

Managerial problems of maintenance and enforcement can be expected to increase, particularly on public lands where freedom from regulation has been an important element of dispersed recreation activities. On some public lands, for instance, restrictions are being placed on off-road vehicular use, while limitations on the backcountry use of some National Forests now include restrictive regulations on camping and open fires, party size, and length of stay.

Managers are also faced with increasing conflicts between recreationists on public lands and the owners of adjacent private property who are sometimes plagued by trespassing and destructive behavior. These conflicts dissuade private property owners from allowing the access necessary to public lands if the opportunities for dispersed recreation are to be maximized.

Developed land activities — Development of recreation sites on forest and range lands has provided an expanded range of recreational opportunities. On public lands, site development now focuses on service facilities that serve the public. Recreational use tends to be concentrated around special scenic or recreation features, facilities, or travel routes. For instance, Yellowstone National Park has about 95 percent of its total use on a few easily accessible and highly popular spots comprising 1 percent of its total area. And on National Forests, developed recreational sites account for 36 percent of total recreational use, but only 0.3 percent of National Forest lands.

The development of recreational sites can be the result of any number of factors. In the past, recreational homes on both public and private lands enabled individuals to enjoy the scenic and recrea-



Outdoor recreational use tends to be concentrated around recreational facilities.

tional values of forest and range lands. More recently, recreational home development has been mostly limited to private lands. At the present time, an estimated 10 percent of all households in the United States own recreational property.[30]

Sites on public lands are developed with facilities because of their specific capabilities, such as scenic values, or to permit uses otherwise unavailable because of fire hazards or fragile environments. Some sites, such as campgrounds and picnic areas, provide services like safe drinking water, sanitation facilities, and other conveniences which are necessary for maintaining some recreation opportunities.

Sites may also be developed on public lands at a central location, such as a visitor center, in order to inform and to educate visitors. For many people, visitor centers, with the associated interpretive services, are an important part of the outdoor recreational experience. Over 500 such centers are now located on Federal lands. These facilities are often concentrated in areas of especially high use and help to orient visitors to recreational opportunities, to interpret the national and cultural history of the area, and to develop an appreciation for the basic ecology, management, use, and protection of the Nation's forest and range lands. In so doing, interpretive services fulfill an important role by encouraging user self-regulation while enriching the recreational experience.

The nature of developed recreational sites is such that a number of opportunities may be available which induce entrepreneurs to provide services on either public or private lands. Because developed and dispersed recreational activities are often complementary, such site development can contribute to the availability of a wide range of recreational opportunities, which, in turn, can promote a private operation's success. For example, campgrounds may serve as a focal point for the placement of trail heads or visitor centers as well as a prime area for rest and relaxation.

Large numbers of developed outdoor recreation areas appear throughout the United States. For instance, there were 15,852 campgrounds listed in the Rand McNally directory in 1977[31] (table 3.8). The private sector supplies a majority of the campgrounds in the North and South, while a majority of the campgrounds in the Rocky Mountains and Great Plains and Pacific Coast States are public. In the public sector, the Forest Service supplied 43 percent of the campgrounds; States, 26 percent; local governments, 10 percent; and the National Park Service, 5 percent.

Generally, public campgrounds have placed greater emphasis on scenic and other qualities of the natural environment, while private campgrounds tend to provide more convenience facilities. This situation is reflected in 1977 Woodall statistics which indicate that three-fourths or more of all private campsites had electricity and water.[32] By comparison, less than one-fourth of the public sites had electricity, and one in ten had water at each site. The basic camp site fee at private campgrounds averaged $4.60 in 1977, while the fee at public campgrounds averaged $3.22.[33]

These campgrounds may accommodate either tents or recreational vehicles or both. The tent has been the traditional shelter for many years, but, by 1976, the use of recreational vehicles had surpassed that of tents. Nonetheless, there are some indications from recent surveys that tents may be regaining their former popularity.[34] The tent camper generally requires a site offering flat ground, water, sanitary facilities, tables, and fireplaces. By comparison, recreational vehicles require a level place to park, facilities for depositing wastes and refilling with fuel and water, and usually an electrical hookup. Campsites usually cost in the range of $2,500 to $10,000.

[30] Ragatz, R. L. Private seasonal-recreational property development and its relationship to forest management and public use of forest lands. Unpublished report for the Southeastern Forest Experiment Station. 301 p. 1978.

[31] Rand McNally and Company. Rand McNally campground and trailer park guide. Editors' annual. Chicago, Ill. 1973 and 1977.

[32] Woodall Publishing Company. Woodall's campground directory, 1977. North American edition. Highland Park, Ill. 1977.

[33] Rand McNally campground and trailer park guide, *op. cit.*

[34] Kottke, M. W., and M. I. Bevins, G. L. Cole, K. J. Hock, and W. F. LaPage. Analysis of the campground market in the Northeast, report III: A prospective on the camping-involvement cycle. U.S. Department of Agriculture, Forest Service, NE Forest Experiment Station, Upper Darby, Pa. Research paper NE-322. 1975.

Table 3.8 — *Number of campgrounds in the United States by section and region and ownership, 1973 and 1977*

Section and region	Ownership					
	Total		Public		Private	
	1973	1977	1973	1977	1973	1977
North:						
Northeast	2147	2265	469	476	1678	1789
North Central	3154	3314	1340	1351	1814	1963
Total	5301	5579	1809	1827	3492	3752
South:						
Southeast	1543	1632	400	435	1143	1197
South Central	1932	1957	955	1012	977	945
Total	3475	3589	1355	1447	2120	2142
Rocky Mountains and Great Plains:	3673	3526	2228	2230	1445	1296
Pacific Coast:						
Pacific Northwest	1510	1447	1036	1003	474	444
Pacific Southwest	1803	1711	1067	1062	736	649
Total 3313	3313	3158	2103	2065	1210	1093
Total United States	15762	15852	7495	7569	8267	8283

Source: Rand McNally and Company. *Rand McNally campground and trailer park guide.* Chicago, Illinois, 1973 and 1977 edition. Annual

In Europe, lodging and meal facilities are commonly spaced along well-traveled trails. In the U.S., hikers and trail riders must provide their own shelter and meals in most areas.

The variation in costs is caused by such factors as level and scale of development, types of pollution-control measures needed, and local land values.

The most significant growth in the supply of developed land opportunities occurred during the sixties and early seventies. The slow growth in facilities in recent years can be attributed to the significant increases in development costs. Also, there appeared to be an overexpansion of the number of recreational facilities, such as campgrounds, in the early seventies. For instance, a nationwide campground occupancy monitoring system, established by the National Campground Owners Association, indicated that average occupancy for the summer season was only 58 percent in 1978.[35] The long-term, break-even point is estimated at approximately 65 percent.

Discussion continues over defining the proper roles of the private and public sectors in meeting demands for developed facilities such as campgrounds. Sentiment in the public sector has been increasingly one of leaving the development of more capital-intensive, convenience-oriented facilities to the private sector.

Issues are also evolving over the expansion of other facilities. For example, in Europe, lodging and meal services are commonly spaced along well-traveled trails to provide hikers with a combination back-country and social experience. Proponents claim that such systems aid resource managers in minimizing undesirable use impact on natural resources and other uses. Currently, the only United States hut system of any significance is one maintained by the Appalachian Mountain Club in New Hampshire's White Mountain National Forest. The Club's system of eight huts provides bunkroom lodging and staff-served meals. During nonsummer months, hikers provide their own bedding and meals, although an Appalachian Mountain Club caretaker may be present.

Attitudes toward developing more hut systems in the United States are mixed. Persons in favor of developing overnight hut systems cite hiker convenience and more effective management, while those opposed to hut systems feel that such facilities contribute to a lower quality backcountry experience and do not belong on public lands.

Alternative facilities that could provide similar types of opportunities are hostels on private lands linked by travel routes across public lands. Hostels are a European travel lodging system that lies somewhere between camping and the motel-hotel system. The hostel movement has become an international

[35] Brown, T. L. and B. P. Wilkins. A study of campground business in New York. Dep. Natural Resources, Research Series No. 2. 1975.

movement and has spread to 49 nations.

More than 4,500 hostels are now in operation worldwide where traveling members can find a dormitory bunk and communal kitchen. These hostels include barns, castles, homes, old churches, railroad stations, hotels, a three-masted sailing ship, and even a former city jail. So far, however, growth of United States hostels has been slow with few hostels outside the Northeast and North Central regions. Of the present 194 hostels chartered in the United States, 81 are actually motels or hotels which give hostelers a discount.

The projected growth of the recreational properties market also has definite ramifications for the use of forest and range lands. Currently, about 3.5 million families in the United States own vacation homes, which receive approximately 700 million person-days of use a year. Present estimates are that between 12 and 15 million recreation lots, representing 6 million acres of land, have been subdivided in the United States.[36] It is estimated that only one-third to one-half of these lots have been sold. Regional trends in the supply of recreational lots can be inferred from statistics on recreational land projects containing more than 50 lots and marketed to consumers outside the State in which they are located. Figures suggest that 82 percent of these projects are located in the western and southern United States with half of all recreational land projects in four States: Florida, Texas, Arizona, and California.

Most vacation home developments are located within or near environmentally attractive areas and can have significant impacts on those areas, especially on lands that are publicly owned. For example, properties in close proximity to public land, such as those set aside for wilderness, are especially appealing to developers who assume that this land will remain in an undeveloped primitive state. While these locations ensure that a wide variety of recreational opportunities are available to the recreational property owner, they can create problems for others. Impacts which can result include environmental problems, such as pollution, man-caused fires, the disruption of wildlife, and increased use pressure on public lands; the visual impacts of roadways and power, pipe, and communication lines; and administrative problems, such as impacts on resource management activities, increased administrative costs, and obstacles to land acquisition.

Equally important are the impacts of recreational property development on local communities. Often, local governments can derive substantial revenues from new developments, while the initial costs of utilities, roads, police and fire protection, and other services are low. These costs can be expected to rise over time, however. In the case of schools, educational costs may exceed tax revenues if an influx of families with school-aged children occurs. Other local impacts may include the lack of commercial and industrial bases from which rural governments can draw taxes, and perhaps most significantly of all, the transformation of traditional rural cultures and lifestyles (which attract the property owner in the first place) to a more urban environment.

Water activities — Over 12 million recreation boats are owned and used in the United States (table 3.9). This represents an increase of 34 percent between 1973 and 1976. The North Central region experienced the largest increases in recreational boat ownership, followed by the Pacific Northwest.

One factor associated with the increasing interest in the use of water for outdoor recreation is the reduction of pollution in many waterways. This has been achieved by legislation such as the Water Quality Act of 1965 and the Federal Water Pollution Control Act Amendment of 1972. The improvement of recreational opportunities through pollution abatement has been particularly significant near urban areas. Other probable factors stimulating participation in water-based recreation include the seemingly crowded conditions associated with other alternative recreational activities; rising energy prices and uncertain supplies that have focused attention on close-to-home recreational pursuits; a growing number of books, magazines, films, and advertisements about water-related activities; and growth in the number of boat liveries and commercial outfitters that provide relatively inexpensive services.

Presently, it is virtually impossible to fully assess the supply situation for water activities in the United States. Despite attempts by States to define their water resources in statewide comprehensive outdoor recreation plans, inventory data frequently are based on varying assumptions and definitions. Consequently, data cannot be aggregated among States and collection agencies. Supply data seldom reflect the suitability of the water for various recreational activities and pursuits.

One may, however, assume that nearly all of the Nation's 2 million rivers and streams are available for recreational use, either for direct or indirect water activities. This supply of waterways totals more than 3.2 million linear miles. Approximately 30,000 miles of that total have been displaced by reservoirs. This condition often has resulted in conflicting viewpoints among persons with varying perspectives as to appropriate use of available resources. In some areas

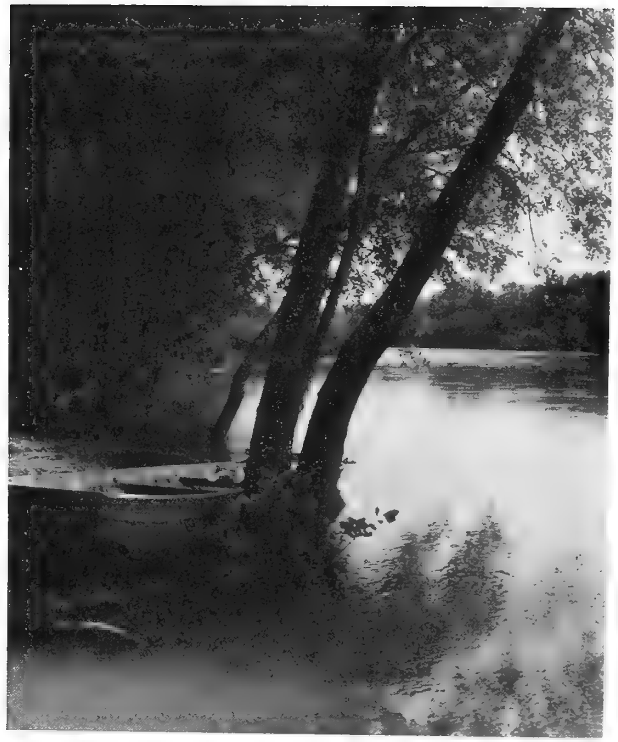
[36] Ragatz, R. L., *op. cit.*

Table 3.9 — *Ownership of recreational boats in the contiguous United States, 1976, percent increase from 1973, by section and region*

Section and region	Ownership of recreational boats		Increase from 1973 to 1976
	1973	1976	
	Thousands	*Thousands*	*Percent*
North:			
Northeast[1]	2,330	2,510	7.7
North Central	2,460	3,900	58.5
Total	4,790	6,410	34.9
South:			
Southeast	1,340	1,750	30.6
South Central	1,710	2,310	35.1
Total	3,050	4,060	33.1
Rocky Mountains and Great Plains	570	790	38.6
Pacific Coast:			
Pacific Northwest	430	630	46.5
Pacific Southwest	670	860	28.4
Total	1,100	1,490	35.5
Total contiguous United States	9,510	12,750	34.1

[1] Includes Washington, D.C.

Source: Personal Communication (A. J. Marmo) Policy Planning and Information Analysis Staff, Office of Boating Safety, United States Coast Guard, Department of Transportation.



There is strong public pressure to preserve rivers and streams with high scenic and recreation values.

— particularly parts of the Pacific Southwest and South Central regions — the modification of drainage patterns in this way has been well accepted, because it has led to increased variety and diversity of recreational opportunities.

Strong public pressure to preserve rivers and streams with high scenic and recreational values currently exists. This is evident by the inclusion of many rivers under Federal and State river preservation programs. The National Wild and Scenic Rivers Act of 1968 designated eight rivers (or portions thereof) as the nucleus of a National Wild and Scenic Rivers System and designated 27 other rivers to be studied as potential additions (fig. 3.6). Since that time, additional amendments to the Act have added other rivers to the System as well as designating additional rivers for study as potential components of the System.

As of January 1978, 28 rivers or river segments totalling 2,318 miles were in the National Wild and Scenic Rivers System. Forty-eight additional rivers also were being considered as potential components of the System. Principal management responsibilities rest with the Forest Service, National Park Service, and the Bureau of Land Management, as well as State governments. Pressures to preserve more rivers under this program will likely continue.

In addition to the National System, 24 States have authorized wild and scenic river systems. The most recent was established by South Carolina in 1974. To date, about 20 States have designed over 120 rivers. All of the States have identified at least some potential candidates. Programs range from active, dynamic planning programs to minimal efforts at initiating such programs.

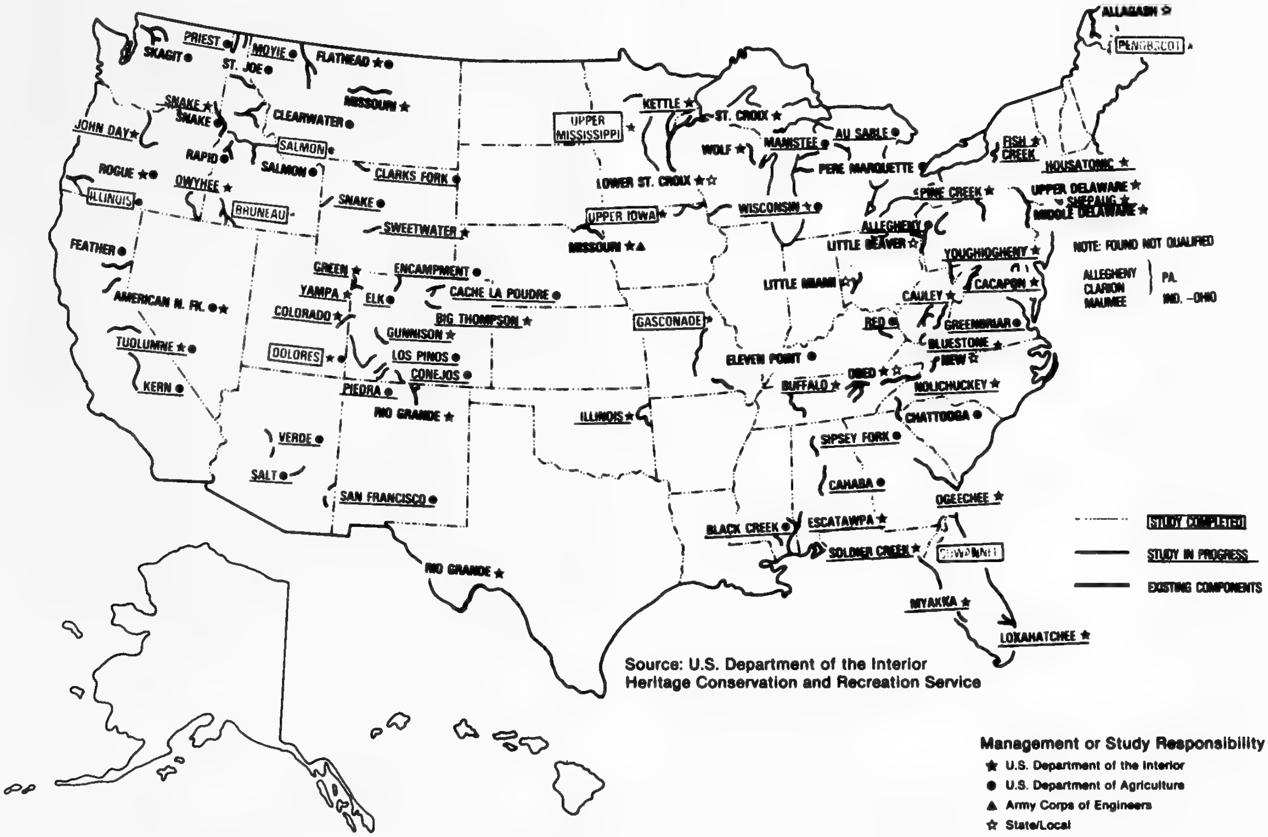
Besides those rivers reserved under Federal and State programs, thousands of other waterways throughout the country have considerable potential for river recreational use — many of which could offer the user the feeling of being in a relatively wild place. Many of these rivers and streams are located on public lands, particularly on the National Forests.

The continued popularity of rivers, streams, lakes, and reservoirs for recreation has created conflicts and problems not only for users and managers, but also for many segments of society. Frequent debates have centered around the appropriate use of water resources. Efforts to curb pollution and to improve water quality have been based partly on demands for recreation. Also common are the conflicts between recreational uses and nonrecreational uses of water such as commercial fishing and trapping, transportation, hydropower, irrigation, water supply, and

Figure 3.6

National Wild and Scenic Rivers System, September 1, 1979

As Authorized by P.L. 90-542 as Amended



Source: U.S. Department of the Interior
Heritage Conservation and Recreation Service

waste-water treatment. Other conflicts that have arisen among recreational uses and nonrecreational riparian uses take place with regard to forest industries, mining, agriculture, and residential land use.

New problems, both social and environmental, have been created by the increased number of recreational users. Many rivers, reservoirs, and lakes are faced with accelerated and unregulated shoreline development which could degrade water quality, restrict public access, and impair natural beauty. Increased recreational use may adversely affect plants, birds, and animals along rivers. Erosion of banks, campsites, and boat landings is a common problem in some locations. Growth in use without proper administration may result in more littering and vandalism to public and private property along waterways. The extent of sanitation, maintenance, and law enforcement may also be expected to increase.

Periodic crowding on some waterways may lessen the enjoyment of some users. Even small changes in the densities and kinds of river uses could greatly influence the quality of experiences for some visitors. In fact, people seeking low-density use and a solitary enjoyment of nature may be displaced altogether. Conversely, crowds appeal to some people, and certain river users may also enjoy the sociability afforded by crowds.

Recreational use often generates other conflicts in addition to crowding. Conflicts have arisen between anglers and boaters, between motorized and nonmotorized boaters, and between recreationists and private landowners. As uses increase, conflicts will probably grow and so will debate over how to mediate such conflicts.

Probably the most serious and immediate water recreation management problems involve conflicts

among and between recreational users and nonrecreational users. These problems are acute for managers of public lands — particularly the Forest Service and Bureau of Land Management. Problems are changing fast, faster than techniques are being developed to cope with them, and probably faster than changes to the natural, biological system resulting from recreational use. Unfortunately, less is known about river, reservoir, and lake users than about their impact on the physical resources.[37]

In the absence of full documentation of recreational use, many decisions have been made intuitively by recreation planners and managers to minimize problems and to maintain quality recreational opportunities. For example, some States in the North Central region have found it necessary to limit the time of day that motorboats may be operated on some lakes in order to assure anglers that they can enjoy reasonably safe and productive fishing experiences. In numerous other situations, waters have been zoned to provide or to limit various boating activities. Also, use rationing on rivers through limitations on camping and open fires, party-size restrictions, limitations on length of stay, and other use restrictions have been imposed or are anticipated. Daily launch limitations (controlling the number of groups permitted to start per day at an access point) and party-size restrictions are common measures for controlling use on about 30 rivers or river segments in the United States.[38] Some management strategies seem to have worked well and have gained public support; many others have not. Managerial action frequently has been reflected both in dissatisfied recreational users and in litigation by a variety of recreation interests.

Snow and ice activities — Snow and ice activities attract participants from all regions of the country. However, individuals from the Rocky Mountains and Great Plains region and the Pacific Coast are more likely to participate in downhill skiing, while individuals located in the Northeast and North Central regions are more frequent participants in ice skating and sledding.[39] For activities like snowmobiling and cross-country skiing, persons living in the Rocky Mountains and Great Plains, North Central, and Northeast have participation levels greater than those in other regions.

These cold weather activities attract a cross section of people, with a growing number of families and older individuals becoming participants. These trends are supported by the 1977 National Outdoor Recreation Survey[40] which showed that downhill skiing, cross-country skiing, and snowmobiling were among the top activities that individuals who are not currently participants would like to try in the future (table 3.1). A national survey of the skiing market conducted by the Forest Service in 1978 indicated that 11 million adults are active downhill skiers.[41] Also, about 4 million adults participate in cross-country skiing.

The supply of snow and ice recreational activities can be divided into two basic types. Developed opportunities are provided for such activities as downhill skiing and ice skating in winter sports complexes which often charge fees for the use of their facilities. For example, the cost of a lift ticket for a day of downhill skiing ranges from $8 to $16. These developed areas vary in size from small community facilities to major corporate ventures which support communities and serve international clientele. Dispersed cold weather recreational opportunities include activities such as cross-country skiing, snowmobiling, snowshoeing, mountaineering, ice fishing, and general snow play in undeveloped areas. Access, parking, sanitation facilities, trails, weather and safety information are normally needed for these activities.

For downhill skiing, the supply of facilities depends on suitable access, terrain, and weather conditions that will give adequate snowfall. In some cases, snowmaking machines are used to extend the season or range. There are 2,246 ski lifts in the United States of which 1,337 are aerial (table 3.10). Forty-one percent are located in the Northeast and 22 percent in the Rocky Mountain and Great Plains States. The Forest Service, the largest public supplier of downhill skiing opportunities, has 30 percent of all the Nation's ski lifts operating under permit by concessioners.

The number of ski lifts is not, however, an accurate measure of the downhill skiing opportunities or the capacity of a region. A long lift going to the top of a steep hill provides a longer ride and a more challenging skiing experience than does a short lift to the top of a gentle hill. The concept of "vertical transport feet" has been developed to provide a more meaningful interpretation of capacity.

The measurement of lift capacity in terms of verti-

[37] Anderson, Dorothy H., Earl C. Leatherberry, and David W. Lime. Annotated bibliography on river recreation. USDA For. Serv. Gen. Tech. Rep. NC-41, North Central For. Exp. Sta., St. Paul, Minn. 62 p. 1978.

[38] McCool, Stephen F., David W. Lime, and Dorothy H. Anderson. Simulation model as a tool for managing river recreation. USDA Forest Service. Gen. Tech. Rep. NC-28, North Central For. Exp. Sta., St. Paul, Minn. 8 p. 1977.

[39] 1977 National Outdoor Recreation Survey, *op. cit.*

[40] 1977 National Outdoor Recreation Survey, *op. cit.*

[41] LaPage, W., and Standley, S. Growth potential of the skier market. USDA For. Serv. (In press).

cal transport feet reveals a different pattern of relative downhill skiing opportunities among the regions (table 3.10). Because longer lifts and steeper mountains are common to the western States, these States generally produce more capacity per lift than lifts located elsewhere. For example, while the Rocky Mountain and Great Plains region has 22 percent of the total number of lifts, this represents 34 percent of the capacity in vertical transport feet. Similarly, the National Forest percentage of capacity in vertical transport feet increases from 30 percent for the number of lifts to 54 percent of the national study.

A cross-country ski trail network has been developed in the last 10 years through the efforts of public agencies and private enterprise. Much of this trail system is comprised of those snow-covered roads and hiking trails used by both cross-country skiers and snowmobilers. Although in some areas snow- and cross-country skiers recreate in relative harmony, in others the quiet recreational encounter sought by some skiers is disrupted by passing snowmobiles. The creation of specially designed trails on some public lands for cross-country skiing reflects the sensitivity of land managers to this situation. Altogether, the supply of trails for cross-country skiing totals 3,442 miles on National Forest lands. So far, these trails have been relatively inexpensive to construct.

Despite the significant progress made in the last decade, prospects for increasing opportunities for snow and ice recreation are not all favorable. The most controversial issue deterring further development is the allocation of public lands for specific uses. An example is the development of downhill skiing facilities. National and local groups have effectively prevented the development of most new ski areas on public land from being approved. Initially, ski area developments were not controversial, because they were few in number and did not create major impacts. It was not until the sixties that such impacts as extensive private land development, the need for expanded community services, and environmental damage were noticed. Since then, planning and construction controls have lessened direct environmental effects of developed ski slopes.

Current issues concerning new developments on public lands relate less to the site itself than to the overall character changes in the area. These issues include such impacts as development encroachment on unroaded or undeveloped areas of public land, development of new communities and changes in existing ones, proliferation of second-home developments, and the effects of these developments on water and air quality. Coupled with these concerns is the long planning period required on public lands for these types of developments. Figure 3.7 illustrates the timing and extent of various aspects of planning, financing, and construction that are necessary to develop a major resort under current conditions on a National Forest. The cost of planning a development of this type is estimated to be over $500,000, excluding private land options and carrying costs. Overall costs to the investors for a 4-year planning effort at Ski Yellowstone, Mont., was reported in 1978 to be $2 million. Those individuals have no assurance of any return on their investment.

Because of these development issues, construction of winter sport complexes featuring downhill skiing has slowed on public lands. Only one new site, Beaver Creek, Colo., is scheduled to open in 1980, and it has been in the planning stage since 1970. The future of other areas in various phases of planning is uncertain. Several key areas that have undergone intensive analysis will probably not be developed in the foreseeable future because of land-use conflicts or the inability of the private sector to continue studies and investment with little hope of a return. Until land-use allocation questions are resolved, most ski lift expansion will have to occur within existing special-use permit areas or on private lands.

The problems associated with increasing opportunities for dispersed snow and ice activities differ from the developed ones. Although land-use allocations can significantly affect such activities as snowmobiling, environmental effects and social impacts caused by cross-country skiing and snowmobiling are relatively minor when compared to winter sport complexes. However, with increasing interest in these activities, a loss in solitude and more frequent disruptions of wildlife are occurring in some locations. Also, conflicts have arisen between cross-country skiers, snowmobilers, recreationists, and private landowners, particularly those whose land adjoins public lands. Some of these problems occur because rights-of-way currently used by snowmobilers and cross-country skiers are informal and without full legal status. Also, there is a concern, especially in the northeastern States, that access to private lands for snowmobiles and cross-country skiers may be curtailed. Rights-of-way, agreements with States for payment, and insurance have reduced this concern, but a long term problem still exists.

Snow avalanches, which are killing an increasing number of snowmobilers, cross-country skiers, mountain climbers, and others each year, constitute another growing problem. Research findings attribute this increase to one cause. More and more people are venturing into steep mountain terrain. With the desire to get away from crowds and ski lift expenses,

Table 3.10 — *Total number of ski lifts and lift capacity operating in the United States by land ownership, section, region, and State, 1978*

Section, region and State	Total				Forest Service land				Other			
	Lifts		V.T.F.H.[1]		Lifts		V.T.F.H.[1]		Lifts		V.T.F.H.[1]	
	Aerial	surface	Aerial	surface	Aerial	surface	Aerial	surface	Aerial	surface	Aerial	surface
	Number		*Millions*		*Number*		*Millions*		*Number*		*Millions*	
North:												
Northeast:												
Connecticut	13	11	6.9	1.7	0	0	0	0	13	11	6.9	1.7
Delaware	0	0	0	0	0	0	0	0	0	0	0	0
District of Columbia	0	1	0	0.5	0	0	0	0	0	1	0	0.5
Maine	23	32	17.4	11.8	3	0	1.9	0	20	32	15.5	11.8
Maryland	2	3	0.8	0.8	0	0	0	0	2	3	0.8	0.8
Massachusetts	27	55	14.9	10.5	0	0	0	0	27	55	14.9	10.5
New Hampshire	64	59	48.0	13.6	19	5	17.1	1.1	45	54	30.9	12.5
New Jersey	21	3	9.9	0.4	0	0	0	0	21	3	9.9	0.4
New York	112	175	67.2	36.8	0	0	0	0	112	175	67.2	36.8
Pennsylvania	68	68	30.6	11.6	0	0	0	0	68	68	30.6	11.6
Rhode Island	3	2	0.6	0.6	0	0	0	0	3	2	0.6	0.6
Vermont	95	70	88.4	18.9	30	8	22.0	2.1	65	62	66.4	16.8
West Virginia	6	5	4.7	0.5	0	0	0	0	6	5	4.7	0.5
Total	434	484	289.4	107.7	52	13	41.0	3.2	382	471	248.4	104.5
North Central:												
Illinois	8	4	2.5	0.3	0	0	0	0	8	4	2.5	0.3
Indiana	0	6	0	1.2	0	0	0	0	0	6	0	1.2
Iowa	2	2	1.3	0.4	0	0	0	0	2	2	1.3	0.4
Michigan	107	65	40.5	10.4	3	6	2.0	0.8	104	59	38.5	9.6
Minnesota	47	35	15.5	8.0	0	0	0	0	47	35	15.5	8.0
Missouri	0	1	0	0.1	0	0	0	0	0	1	0	0.1
Ohio	20	15	5.8	2.3	0	0	0	0	20	15	5.8	2.3
Wisconsin	76	35	22.8	8.1	0	0	0	0	76	35	22.8	8.1
Total	260	163	88.4	30.8	3	6	2.0	0.8	257	157	86.4	30.0
Total, North	694	647	377.8	138.5	55	19	43.0	4.0	639	628	334.8	134.5
South:												
Southeast:												
Florida	0	0	0	0	0	0	0	0	0	0	0	0
Georgia	1	0	0.3	0	0	0	0	0	1	0	0.3	0
North Carolina	19	4	10.5	0.6	0	0	0	0	19	4	10.5	0.6
South Carolina	0	0	0	0	0	0	0	0	0	0	0	0
Virginia	13	6	5.3	0.6	0	0	0	0	13	6	5.3	0.6
Total	33	10	16.1	1.2	0	0	0	0	33	10	16.1	1.2
South Central:												
Alabama	0	0	0	0	0	0	0	0	0	0	0	0
Arkansas	0	0	0	0	0	0	0	0	0	0	0	0
Kentucky	1	0	0.3	0	0	0	0	0	0	0	0.3	0
Louisiana	0	0	0	0	0	0	0	0	0	0	0	0
Mississippi	0	0	0	0	0	0	0	0	0	0	0	0
Oklahoma	0	0	1.9	0.1	0	0	0	0	0	0	1.9	0.1
Tennessee	7	1	0	0	0	0	0	0	7	1	0	0
Texas	0	0	0	0	0	0	0	0	0	0	0	0
Total	8	1	2.2	0.1	0	0	0	0	8	1	2.2	0.1
Total, South	41	11	18.3	1.3	0	0	0	0	41	11	18.3	1.3

Table 3.10 — *Total number of ski lifts and lift capacity operating in the United States by land ownership, section, region, and State, 1978 — continued*

Section, region and State	Total				Forest Service land				Other			
	Lifts		V.T.F.H.[1]		Lifts		V.T.F.H.[1]		Lifts		V.T.F.H.[1]	
	Aerial	surface	Aerial	surface	Aerial	surface	Aerial	surface	Aerial	surface	Aerial	surface
	Number		*Millions*		*Number*		*Millions*		*Number*		*Millions*	
Rocky Mountains and Great Plains:												
Arizona	5	3	4.3	0.7	2	2	1.7	0.6	3	1	2.6	0.1
Colorado	153	49	172.9	8.8	124	29	136.4	6.1	29	20	36.5	2.7
Idaho	45	22	48.2	7.5	40	13	44.0	3.8	5	9	4.2	3.7
Montana	23	22	23.7	10.6	19	14	20.0	4.8	4	8	3.7	5.8
Nebraska	1	2	0.4	0.1	0	0	0	0	1	2	0:4	0.1
Nevada	11	11	7.3	2.9	4	2	3.4	0.8	7	9	3.9	2.1
New Mexico	24	16	19.4	4.3	17	11	15.5	3.6	7	5	3.9	0.7
North Dakota	0	3	0	0.5	0	0	0	0	0	3	0	0.5
South Dakota	7	12	3.9	2.2	1	2	0.5	0.4	6	10	3.4	1.8
Utah	55	5	58.3	2.0	26	2	29.1	0.4	29	3	29.2	1.6
Wyoming	14	16	16.1	3.5	11	11	12.7	2.6	3	5	3.4	0.9
Total	338	161	354.5	43.1	244	86	263.3	23.1	94	75	91.2	20.0
Pacific Northwest:												
Alaska	7	7	7.5	1.2	5	2	5.8	0 2	2	5	1.7	1.0
Oregon	29	12	27.6	2.8	28	10	26.6	2.5	1	2	1.0	0.3
Washington	59	14	53.1	4.9	54	7	48.6	4.3	5	7	4.5	0.6
Total	95	33	88.2	8.9	87	19	81.0	7.0	8	14	7.2	1.9
Pacific Southwest:												
California	169	57	135.2	10.8	125	34	100	7.1	44	23	35.2	3.7
Hawaii	0	0	0	0	0	0	0	0	0	0	0	0
Total	169	57	135.2	10.8	125	34	100	7.1	44	23	35.2	3.7
Total, Pacific Coast	264	90	223.4	19.7	212	53	181	14.1	52	37	42.4	5.6
Total, United States	1,337	909	973.0	202.6	511	158	487.3	41.2	826	751	485.7	161.4

[1]Vertical transport feet (V.T.F.H.) is an expression of capacity. One vertical transport foot is the capacity to raise one skier vertically one foot per hour.
Source: Dufresne - Henry Engineering Corporation. *United States ski area growth statistics 1963-1977.* North Springfield.

many people are entering areas that previously had not seen a climber, skier, or snowmobiler. With more people taking risks, the number of avalanche victims can only increase as long as information and management controls are inadequate.

Implications of Supply and Demand Comparisons

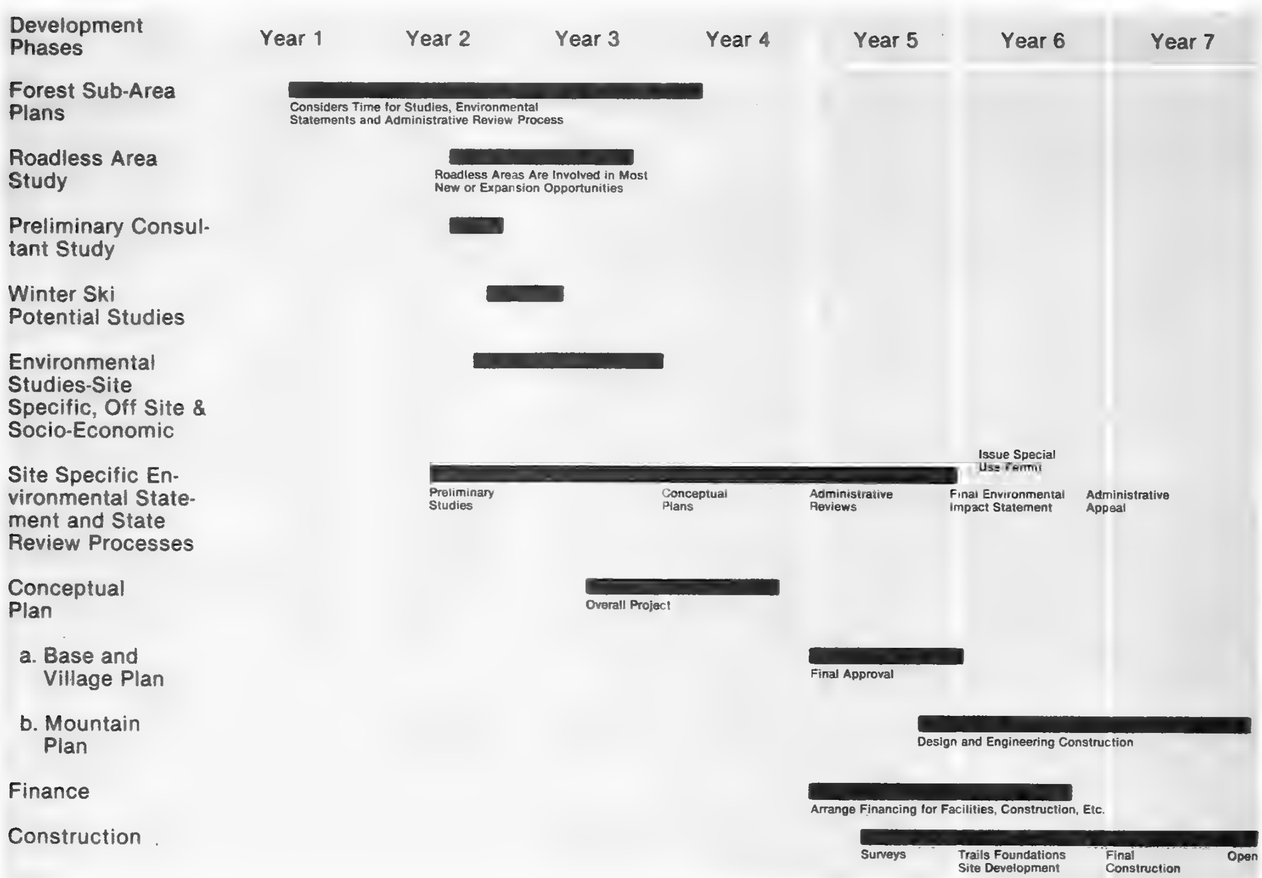
The substantial growth in outdoor recreational participation projected for all the activities studied in this assessment has important implications for the future use of the Nation's forest and range lands. In the past, the supply of outdoor recreational opportunities has been generally sufficient to meet public demands for a variety of recreational experiences. Both the public and private sectors have made important contributions in providing a wide variety of recreational opportunities.

Future expansion of the Nation's recreational resources will be necessary, however, if adequate opportunities are to be ensured. Demand for snow and ice activities is expected to show the most pronounced increase, closely followed by water and then land activities. For land activities, projections suggest large increases in participation in the South Central and Pacific Southwest regions, whereas modest increases can be expected in the Northeast and North Central States. For snow and ice activities, most regions in the North and West exhibit increases, especially the Pacific Southwest region.

These trends suggest that cleaner water, a greater number of capital-intensive facility complexes, such as those for winter sports, and the preservation of large acreages of natural environment are some of the management concerns that will grow in importance as demands for outdoor recreational opportunities increase. Without sufficient increases in supply, lim-

Figure 3.7

Development Schedule for a Major New Ski Resort



itations on outdoor recreational opportunities will constrain future participation and could lead to degradation of both the physical resource and the recreational experiences it supports.

Traditionally, public lands have provided numerous recreational opportunities. However, increasing needs for water, minerals, energy, and other forest and range products require that the recreational use of these lands vie with other important resource uses. If the public sector is to continue to provide recreational experiences, future plans for the management of public lands must recognize that outdoor recreation has values commensurate with those of other resource elements.

It has become apparent, however, that public lands alone cannot bear the burden which increased demands for outdoor recreation opportunities are placing of them. Even now, the supply of outdoor recreation appears to be limited. The 1977 National Outdoor Recreation Survey identified several factors affecting participation in outdoor recreation. One of the most frequently cited reasons for not participating was the crowded conditions encountered[42] (table 3.11). Other important reasons included the inconvenience of engaging in outdoor recreational activities, polluted and poorly maintained conditions, and the lack of information about available outdoor recreational opportunities.

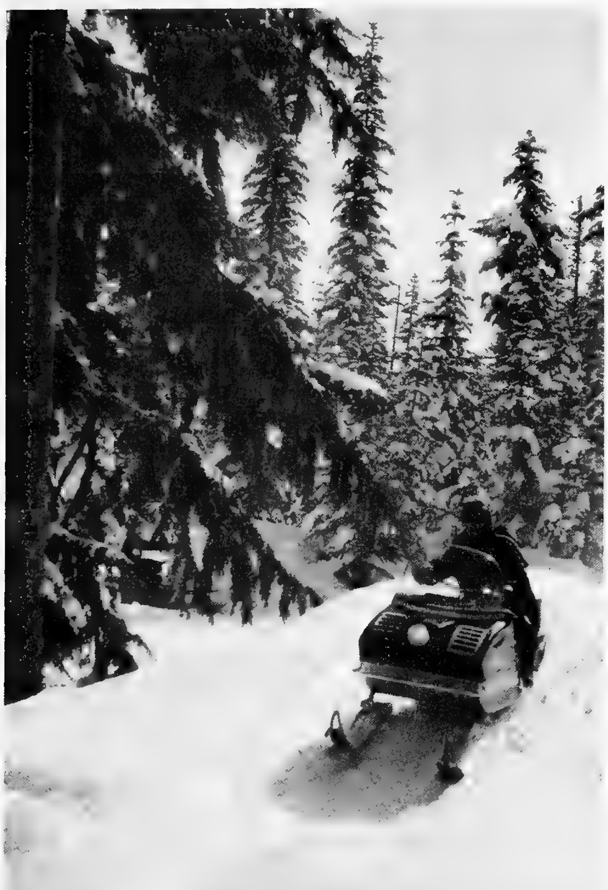
In the future, private lands must provide a larger share of outdoor recreation experiences. In the past, the problems which recreationists create for private landowners, the inability of the private sector to compete financially with public recreation operations, and other factors have limited the availability of private lands for recreational use. Actions to encourage private investment and involve private

[42] U.S. Department of the Interior, Heritage, Conservation and Recreation Service, *op. cit.*

Table 3.11 — *Percent of population not participating in outdoor recreation in the United States by reasons and region*
(Percent)

Reason	National	Northeast	North Central	Southeast	South Central	Rocky Mountains and Great Plains	Pacific Northwest	Pacific Southwest
Crowded	44.3	41.9	46.2	40.7	36.3	46.9	52.3	51.7
Money	35.5	34.2	34.4	35.7	33.2	38.8	35.5	39.4
Information	31.6	35.9	33.8	29.3	29.1	26.8	29.3	29.7
Home recreation	28.5	31.0	32.1	33.1	29.1	23.7	23.3	21.1
Convenience	28.1	30.2	28.5	36.3	25.3	24.4	25.2	26.4
Pollution	23.8	27.3	25.8	25.2	20.6	18.9	19.2	25.3
Interest	20.9	34.4	20.0	24.9	17.5	20.4	18.7	16.4
Poor maintenance	19.5	21.3	21.7	16.4	20.2	18.9	13.8	18.3
Health	19.4	20.8	19.4	15.1	19.1	19.1	19.2	19.2
Transportation	17.8	20.7	18.9	17.0	14.6	15.7	14.4	19.4
Safety	17.7	20.4	18.3	17.0	15.7	14.7	13.6	20.8
Other	1.4	1.1	0.4	2.8	0.9	1.4	1.6	3.1

Source: U.S. Department of Interior, Heritage, Conservation and Recreation Service. *1977 national outdoor recreation plan.* (In process).



Many National Forests and other lands have designated trails or areas for snowmobiles. This is necessary to protect the environment and interests of other users.

landowners in outdoor recreation enterprises will be necessary if the private sector is to expand its role as a supplier of outdoor recreation.

Failure to provide for the prospective growth in demand for outdoor recreation could have impacts on economic development. The production and consumption of recreational goods and services have economic effects at all levels — National, State, and local — and in a variety of forms. Industries producing recreational goods and services — from vacation homes to fishing poles to skiing vacations — stimulate local economies with their business revenues, employment, payrolls, and profits. The resultant cash flows create a rippling effect throughout the economy as earnings are spent on other goods and services by businesses and employees alike. These revenues, in turn, provide a tax base from which moneys for the support of the local, State, and Federal governments are derived; part of these funds are used to further provide public recreation services.

In conjunction with direct sales of recreational goods and services, expenditures accruing to outdoor recreational travel are especially beneficial for local economies. Small communities that are dependent on tourism derive income and jobs from the money spent by recreationists on gasoline, lodging, food, equipment, and various services. A National Travel Expenditure Model developed by the United States Travel Data Center indicates that expenditures for outdoor recreation totalled $11 billion, or 11 percent of total expenditures for trips over 200 miles round trip within the United States.[43]

[43] U.S. Travel Data Center. 1976 National travel expenditure study: Summary report. Washington, D.C. 110 p. 1977.

Related areas of economic development sometimes have substantial impacts on local or State economies by the sale of recreational properties and second homes. The Office of Interstate Land Sales Regulation has estimated the national annual sales of recreational property at roughly $5.5 billion.[44] The growth of this market is most dramatic in areas close to recreational amenities which have caused land values to climb sharply. Summit County, Colo., for instance, has experienced skyrocketing land values from $500 to $8,500 an acre and higher. When these properties are in use, the spending of the seasonal residents can further stimulate the local economy. It is estimated that some 3.5 million second-home households contribute $5.2 billion annually to rural economies where these expenditures are especially significant.

Individual and social benefits of outdoor recreational participation are more difficult to measure, but are equally important for the social well-being of the American public. These benefits include the work-time gained from avoiding such health problems as heart attacks due to greater individual participation in recreation; the lower incidence of crime, especially among youths, because of the availability of outdoor recreation sites, facilities, and programs; and the saved costs to society in health care resulting from a more physically fit population.[45]

One physical benefit of recreation participation is the equilibrium ensured by the rest and relaxation it provides. Research has indicated that escape from the stresses of the home, neighborhood, and job is a prime motivation for recreational participation.[46] Strenuous physical activities, such as swimming or cross-country skiing, serve as relaxing outlets for the tension or relief from the boredom often experienced on the job.

Participation in outdoor recreational activities can also promote feelings of competency and self-fulfillment and, in turn, psychological balance. These benefits are enhanced by the significant educational opportunities that outdoor activities offer. The achievement of making discoveries, taking risks, and meeting challenges in the outdoors improves the individual's self-concept and self-reliance.[47] Evidence that these individual benefits are highly valued can be found in the growing enrollments in such nationally known outdoor experience schools as Outward Bound and the National Outdoor Leadership School as well as in numerous other private and school-sponsored courses.


People of all ages benefit from participating in outdoor recreation activities.

Similarly, social benefits are derived from the social interaction which is often an integral part of the outdoor recreational experience. The affiliation experienced through recreational pursuits fosters personal development, while the family solidarity promoted by shared recreational experiences is basic to social stability.[48] In a society of increasing transient and short term relationships among people, outdoor recreation can provide a common ground which facilitates meaningful interaction among individuals. Outdoor recreation thus provides a means for old friends to strengthen emotional ties while creating opportunities for making new friends.

[44] American Society of Planning Officials with contributions from the Conservation Foundation, Urban Land Institute, and Richard L. Ragatz Associates, Inc. Subdividing rural America: Impacts of recreation lot and second-home development. Prepared for the Council of Environmental Quality, Department of Housing and Urban Development, and the Appalachian Regional Commission. Gov. Printing Office, Washington, D.C. 139 p. 1976.

[45] Newsweek. Keeping fit: America tries to shape up. 89(21):7886.

[46] For a review of such studies, see Driver, B. L., and R. C. Knopf. Temporary escape, one product of sport fisheries management. Fisheries 9(2):21, 24-29. 1976.

[47] Harris, D. V. Perceptions of self. Research Camping and Environmental Education. HPER Series II, The University of Pennsylvania, University Park, Pa. 1977.

[48] Yoesting, D. R., and D. L. Burkhead. Significance of childhood recreation experiences on adult leisure behavior: An explanatory analysis. Journal of Leisure Research 5(1):2536. 1976.

Opportunities for Increasing the Supply of Outdoor Recreation

It is clear that efforts on the part of both the public and private sectors will be necessary to ensure the availability of a wide range of outdoor recreational opportunities on forest and range lands and achieve the benefits described above. Presently, over half of the individuals in the Nation feel that outdoor recreation is a "very important" activity.[49] However, these individuals have a wide variety of motivations, interests, and desires regarding their recreational pursuits.

There are several major opportunities for realizing the full recreational potential of the Nation's forest and range lands. These opportunities include the continued development of the recreation resource, the improved use of the resource, more extensive and effective cooperative activities to enhance the resouces on private lands and their use, and the development of an improved information base for managerial decision-making.

Development of outdoor recreation resource—The greatest opportunity for realizing the recreation potential of lands already used for recreational purposes is the further development of such facilities as trails, campgrounds, picnic areas, and boat ramps. Facility development, when planned and accomplished properly, can contribute to an increase in the quantity, quality, and availability of outdoor recreation opportunities. With proper design and management, these new developments can reduce conflicts among recreationists, minimize damage to other resources, and provide for user convenience and safety. In particular, recreation management must consider the special needs of the elderly and handicapped. As called of for in the Architectural Barriers Act (P.L. 90-480 as amended), an appropriate number of facilities must be made available to special populations.

Trails are an example of a development that can serve a spectrum of uses. The design of a trail and the extent of its maintenance can function to regulate the kinds and intensity of use it receives. Trails that qualify can be designated under the National Trails System Act.

The designation of a trail is a way to promote public knowledge of a trail's existence and availability and to ensure that the trail meets certain construction and management standards. New trails can be developed by taking advantage of abandoned railroad grades, old canal banks, pipelines, utility line rights-of-way, highway corridors, abandoned roads, and undeveloped lands.

Numerous other types of recreational developments could help meet the growing demands for a broad range of recreational opportunities. For instance, boat ramps and designated beaches could provide for participation in water activities. In addition, National Forest and public lands could provide camp areas for such groups as senior citizens and clubs and also day camps to serve young underprivileged urbanites.

Innovative management actions focusing on facility development could include renovation of surplus buildings to create a national system of hostels. Such a system would enable people of all ages to enjoy the outdoors through hiking, cycling, skiing, canoeing, and other recreational activities. Moreover, winter sports complexes could be redesigned to provide a mix of recreational opportunities. For instance, a variety of activities, including downhill and cross-country skiing, skating and snowmobiling, might be served by the same parking, sanitation, and lodging facilities. These areas also could support other forms of recreation during the nonskiing season.

Opportunities to improve use of the resource—Equally important to providing new recreational developments is the provision for the proper maintenance of existing ones. Progressive site deterioration on public lands continues to be a problem, especially at heavily used camping and picnic areas. Rehabilitation programs could aid in solving this problem.

Increasing recreation pressures on forest and range lands could also be eased through efforts ensuring that the recreation resource is used to its fullest potential. Management actions are needed to promote use which is both more evenly distributed over the available resource acreage and productive of the most satisfying recreation experiences possible.

Improving access to the Nation's forest and range lands and waters is one such management action. Lack of public access is often a major obstacle to participation in dispersed and other types of recreational activities. Florida seems to typify the situation in many States. There are more than 12,000 miles of streams throughout the State, and 21 canoeing routes have been designated and publicized by the Department of Natural Resources. Planners there feel that limited public access currently is the main deterrent to further site development. Expanded public access is particularly needed in densely populated urban areas where access often is tightly controlled.

In many areas, expanded access through public ownership of rights-of-way seems to be the best

[49] U.S. Department of the Interior, Heritage, Conservation, and Recreation Service, *op. cit.*

chance to increase and extend resources available for outdoor recreational activities. For example, additional rights-of-way and land acquisition are needed in the Northeast to continue its network of cross-country ski trails.

Providing improved information and education opportunities for outdoor recreationists is also an important opportunity for improving the use of forest and range lands. An informed, educated public could result in more self-regulation and greater user satisfaction. Public information on where to go, how to get there, and what conditions to expect could be provided in the form of maps, signs, and verbal communication. Information could also be made readily available to visitors by establishing information arrival stations, dispensing pamphlets, bulletins, and cassette tapes.

Opportunities to improve cooperative efforts— Cooperative efforts by government agencies, private interests, and individuals — whether in technical assistance or coordinated planning — is one means by which a greater abundance of recreational opportunities can be provided. In the past, the interest and involvement of private individuals and organizations at the grassroots level has helped to stimulate legislation resulting in the designation, development, and protection of the recreation resource. The Appalachian Mountain Club, for example, has been a constructive force in developing and protecting the Appalachian Trail, while other organizations like the American Camping Association have generated pressures influencing public policy on resource management.

A program to exchange technical information and research findings can also help to improve recreational opportunities. Standards, technologies, and designs developed by one agency that enhance recreational opportunities could be utilized by others. Opportunities for expanding expertise include: the establishment of management objectives to ensure the maintenance of visual quality; the design and construction of roads, trails, campgrounds, and winter sports complexes to provide a variety of outdoor experiences; and the modification of operations and the provision of additional facilities to expand the recreational use of reservoirs.

Equally important, private landowners can contribute to the availability of lands suitable for recreation use. Some public corporations have opened their forest and range lands to public recreation while continuing their business operations. These landowners include the Southern Paper Corporation, which has set aside several scenic "pocket wilderness" areas covering 1,636 acres and 29 miles of trail.

Forest industry organizations have also made

Improving access to forest and range lands and waters is one way of meeting projected increases in demands.

significant contributions to the current recreation resource supply. The Texas Forest Association is one such organization. Working with six forest product companies and several individual landowners, it has established a system of woodland trails throughout eastern Texas.

However, more needs to be done if future demands for outdoor recreation are to be met. Cooperative Federal and State assistance to individual landowners can help meet the growing future demand for recreation by adding to the recreation resource base. Nearly two-thirds of the privately owned forest and range lands in the United States is closed to the general public for recreational use. To make this land more accessible and to prevent future closure, problems which now confront landowners must be reduced or eliminated. Among owners with land not open to public recreation, the most cited reason for closure has been interference with other activities. Assistance in activity coordination might help to open more lands to users.

Other reasons for not opening private land to public use have been property damage, disturbance of privacy, and wildlife disturbance. Cooperative programs to reduce these problems and to promote the expanded involvement of landowners could include educating potential users on an appropriate "use

ethic" and providing stronger law enforcement and regulatory measures.

In addition, more positive inducements for landowners could help realize an increase in the amount of private lands offering recreational opportunities. Possible inducements most frequently cited by private landowners and government managers alike include protection from lawsuits, advice on development and operation, tax credit, and insurance (table 3.12).

Table 3.12 — *Conditions under which landowners would open land now closed to recreation use in the United States, by condition and type of ownership, 1978*

(Percent of landowners)

Conditions for opening lands	Private ownership: Corporate	Private ownership: Noncorporate
Under no conditions	29	39
To make a reasonable profit	22	20
With protection from lawsuits	11	16
With tax break incentive	9	4
To improve public relations	7	5
If income equals cost	7	4
If someone else managed	5	2
Provide insurance for liability or loss	4	6
Other	5	4

Source: Cordell, H. Ken., Robert McLellan, Herbert Stevens, Gary Tyre, and Michael Legg. *Existing and potential recreation role of privately owned forest and range lands in the United States: an assessment.* (In process).

Research opportunities. — Effective planning and national decisionmaking regarding proper resource allocation and facility development is a necessity if the Nation's demands for outdoor recreation are to be met. The effectiveness of these processes, however, greatly depends upon the usefulness and accuracy of the information available to resource planners and managers. The inputs of decisionmakers at all management levels are necessary if the kinds of information they need to perform more efficiently and effectively are to be provided.

In general, better information is needed to describe the existing and potential recreation resource, monitor present participation trends, evaluate the outdoor recreation experiences provided on forest and range lands in terms of their social and economic implications, assess relative benefits of various management actions, and provide methods to increase the contribution the forest recreation resource can make to improving the urban environment.

Better descriptive information is needed if a more accurate understanding of both outdoor recreation supply and demand is to be available at all decisionmaking levels — local, regional, and national. On the supply side, the managers' knowledge of resource capability and managerial suitability could be improved with a continuing systematic survey of the recreation resource with standards and specifications used nationwide. Research is needed to develop methods for inventorying those forest and range lands available and suitable for outdoor recreation as well as existing outdoor recreation facilities. Information could also be provided which would help to explain the effect of physical attributes of the resource on specific recreation activity patterns, guide data analysis and interpretation, and determine future recreation supply patterns. Further, studies on increasing the supply of recreation activities on private land could further identify opportunities for cooperation, as well as areas of conflict, between public and private land management agencies.

On the demand side, a standardized, cost-effective method of monitoring trends in use is necessary if planning decisions are to be based on adequate information concerning present and future participation levels. A comprehensive analysis of recreation participation also involves evaluation of special requirements for participation by particular populations. Research is needed to identify barriers which deter participation in outdoor recreation by urban populations, minority groups, and handicapped individuals, and the needs of these people must be more fully considered in future recreation planning. Also, the impacts of the changing energy situation need to be studied.

Managerial decisions must also be guided by an evaluation of the social and economic implications of various management actions. Greater knowledge of the social and economic benefits of outdoor recreation is needed if decisions concerning the allocation of resources and funds are to meaningfully reflect the values which people derive from various recreation experiences.

Knowledge of recreation values is also necessary to guide the coordination and integration of recreation management with other resource uses. Evaluation procedures for determining the tradeoffs being made, in terms of the outdoor recreation and other resource values foregone, are becoming increasingly important as the need grows for integrating recreation uses of forest and range land with other management activities. Basic to such a process is the determination of the nonmarket values of recreation, for which the state of the art lags far behind that for evaluating market commodities such as timber.

Finally, it must be recognized that the outdoor recreation resource is not confined to rural areas.

Trees in the city are becoming increasingly important in upgrading the quality of an urban environment. Open spaces, greenbelts, buffer strips, roadsides, community parks, wooded residential and industrial zones, expanding urban areas, and new communities are all areas of forest recreation research. Many potential benefits, including pleasant and serene environments, increased natural beauty, cooling shade, recreational opportunities, better air to breathe, less street noise, protection from the winds, and more birds and wildlife, are thought to be provided by the urban forest.

Here, additional research is needed to: assess the human benefits from urban forests for recreation and amenity values; develop methods to breed, select, establish, maintain, and protect urban forests from insects and diseases to improve human benefits, and develop strategies to integrate sound urban forest planning and management into the total urban planning and development process.

Wilderness

In the last few decades, the wilderness resource in the United States has received increasing attention. Recreation and other uses of wilderness have grown substantially since World War II, while the land area available for wilderness designation has been reduced by development. In the last decade, few forest and range issues have created as much interest and controversy as the designation of forest and range land as wilderness. This section presents information on (1) the use of forest and range lands as wilderness and (2) opportunities for meeting future demands for wilderness.

The National Wilderness Preservation System

Although the creation of Yellowstone National Park and the Adirondack Forest Preserve were early attempts to protect areas in the United States from traditional development, the first wilderness area — a half million acres in the headwaters of the Gila River on the Gila National Forest in New Mexico — was set aside in 1924 by the Secretary of Agriculture in response to a proposal by Aldo Leopold. Other areas were soon added and by 1940 the system comprised 73 areas.

Various groups sought more permanence in wilderness designations by proposing Federal legislation to establish a national wilderness system. In response to this interest, Congress passed the "Wilderness Act" in 1964, which established a National Wilderness Preservation System composed of Federally owned lands designated as "wilderness areas."

The 1964 Act required all of the areas which had been classified under the Secretary of Agriculture regulations as wilderness, wild, or canoe areas to be designated as wilderness areas. The legislation directed the Forest Service to review all National Forest areas classified as "primitive" and make recommendations to the President and Congress within 10 years as to their suitability for preservation in the national wilderness system. The Secretary of the Interior was directed to review every roadless area of 5,000 contiguous acres or more in the National Parks, National Monuments, and National Wildlife Refuges for possible inclusion in the National Wilderness Preservation System.

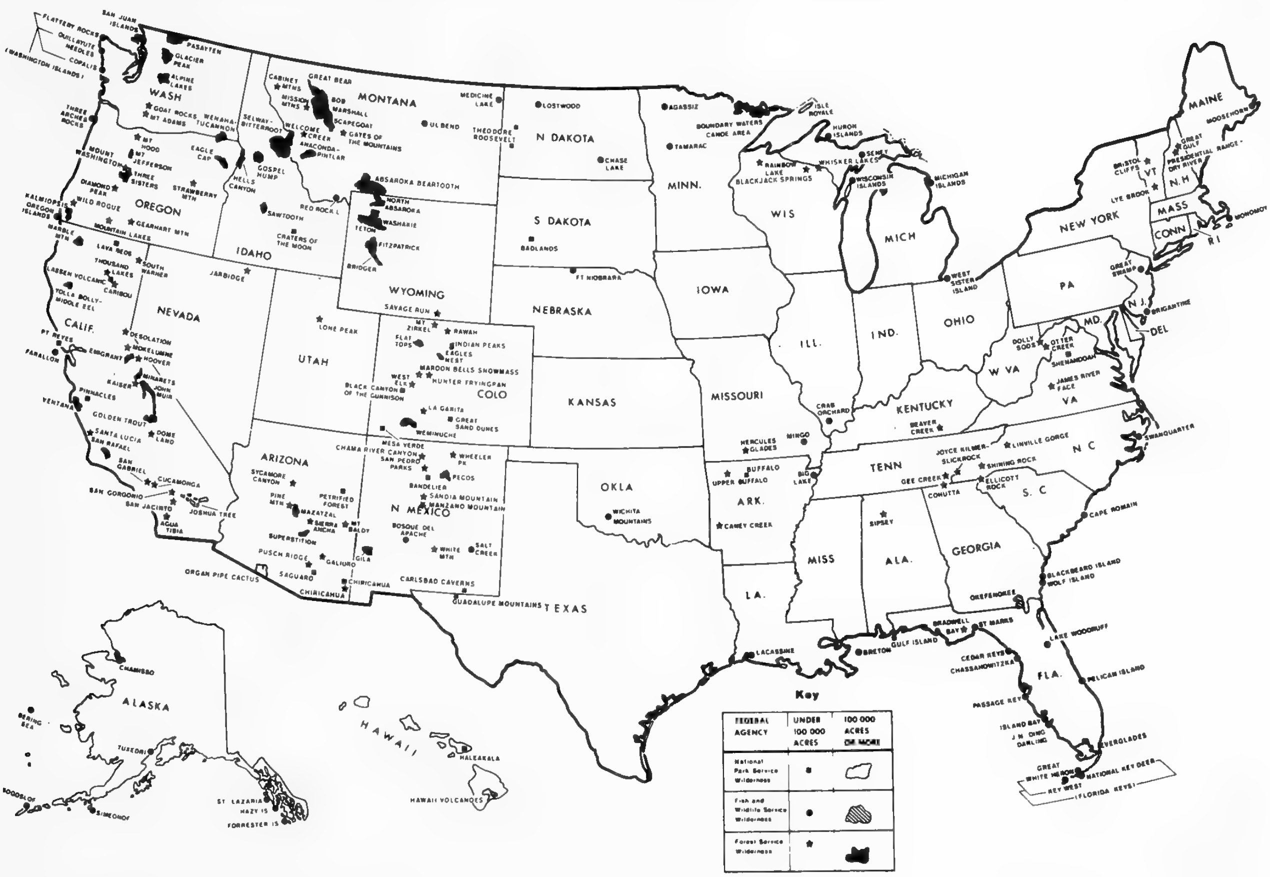
The Wilderness Act of 1964 also declared it to be the policy of Congress "to secure for the American people of present and future generations, the benefits of an enduring resource of wilderness." Congress could designate federally owned areas to be "administered for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness . . ." The Act states that wilderness is "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." Wilderness is further defined in the Act as "an area of undeveloped Federal land retaining its primeval character and influence . . ." and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least 5,000 acres of land or is of sufficient size as to make practical its preservation and use in an unimpaired condition, and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value."

In 1975, a Congressional Act, (P.L. 93622) established 16 wildernesses with a total area of about 171,000 acres east of the 100th meridian. This Act also designated 17 additional areas to be studied for possible inclusion into the National Wilderness Preservation System. The 17 areas cover approximately 125,000 acres. The Act required that the studies be completed and a report made to Congress within 5 years on their suitability.

As of July 1, 1979, 191 Federal wilderness areas containing 19.0 million acres had been designated in the United States (fig. 3.8). About 80 percent of this area is administered by the Forest Service, 16 percent by the National Park Service and 4 percent by the Fish and Wildlife Service. In addition, 12,000 acres of

Figure 3.8

National Wilderness Preservation System, September 1, 1979



public land administered by the Bureau of Land Management have been designated wilderness. As a result of past land development patterns (or more precisely, the lack of development), the designated wilderness areas are concentrated in western States. However, lands within the system, and those under review and study, include areas from all of the major forest and range land ecosystems represented in the United States (table 3.13).

Recreational use of wilderness—In 1978, the National Forest wildernesses received more than 8 million recreation visitor days of use or 4 percent of all National Forest System recreation visitor days. Recreation use on National Park and National Wildlife Refuge wildernesses amounted to another several hundred thousand recreation visitor days.

Wilderness recreation use must be kept at low density levels if unmodified natural conditions are to be protected and if "outstanding opportunities for solitude," as described in the Wilderness Act, are to be maintained. Present use of National Forest wilderness units amounts to about one-half of a recreation visitor day per acre per year. Wilderness managers of different areas experiencing varying use pressures suggest this average may be close to a desirable upper limit for some wildernesses. Carrying capacity, however, is influenced by many factors, such as length of season, number of access points, abundance of trails, or other travel routes, number of camping areas, attractions, fragility of soils and vegetation, and the presence of wildlife sensitive to human use pressures.

The intensity of use varies greatly from wilderness to wilderness. Two National Forest wildernesses each reported about 1 million recreation visitor days of use in 1978—The John Muir Wilderness in California and the Boundary Waters Canoe Area in Minnesota. In contrast, some wildernesses had only a few thousand recreation visitor days of use. Estimated visitor days per acre per year varied in 1978 from a high of about 7 to a low of 0.04. Even allowing for variation

Table 3.13—*Area of the National Wilderness Preservation System (NWPS) and endorsed administration[1] additions in the contiguous United States by ecosystem and managing agency, July 1, 1979*

(Acres)

Ecosystem	Total existing NWPS units	Existing NWPS units			Total endorsed areas	NWPS proposals endorsed by the Administration[1]		
		Managing agency				Managing agency		
		National Forest Service	National Park Service	Fish and Wildlife Service		National Forest Service	National Park Service	Fish and Wildlife Service
Forest land:								
Eastern forest:								
White-red-jack pine	565,837	563,510	0	2,327	2,830	2,830	0	0
Spruce-fir	418,658	250,230	131,880	36,548	235,976	39,070	195,500	1,406
Longleaf-slash pine	39,309	23,432	14,109	1,768	39,230	39,230	0	0
Loblolly-shortleaf pine	0	0	0	0	55,070	54,480	0	590
Oak-pine	115,670	26,990	79,579	9,101	80,153	79,990	0	163
Oak-hickory	125,229	98,420	10,529	16,280	268,681	174,180	90,191	4,310
Oak-gum-cypress	1,278,073	0	823,305	454,768	11,655	10,320	0	1,335
Elm-ash-cottonwood	7,275	0	7,198	77	5,800	5,800	9	0
Maple-beech-birch	61,030	61,001	0	29	270,281	152,660	117,000	621
Total	2,611,081	1,012,483	1,066,600	520,898	969,676	558,560	402,691	8,425
Western forest:								
Douglas-fir	1,465,188	1,464,833	0	355	1,183,910	677,910	506,000	0
Ponderosa pine	1,507,068	1,390,444	114,989	1,635	2,470,546	2,109,040	304,888	56,618
Western white pine	30,808	30,808	0	0	293,600	151,600	142,000	0
Fir-spruce	6,168,970	6,093,937	75,033	0	7,328,799	3,661,195	3,667,604	0
Hemlock-sitka-spruce	0	0	0	0	2,439,900	2,199,900	240,000	0
Larch	484,337	484,337	0	0	0	0	0	0
Lodgepole pine	473,542	473,542	0	0	715,967	103,800	612,167	0
Redwood	25,047	4,751	20,296	0	0	0	0	0
Western hardwoods	77,025	77,025	0	0	26,700	26,700	0	0
Total	10,231,985	10,019,677	210,318	1,990	14,459,422	8,930,145	5,472,659	55,618
Other forest:								
Chapparal-mountain shrub	645,741	614,175	30,605	961	503,890	466,890	37,000	0
Pinyon-juniper	270,311	202,591	67,720	0	1,210,459	650,875	383,874	175,710
Total	916,052	816,766	98,325	961	1,714,349	1,117,765	420,084	175,710
Total, forest land	13,759,118	11,860,026	1,375,243	523,849	17,143,447	10,606,470	6,296,224	240,753
Range land:								
Grasslands:								
Plains grasslands	132,419	0	86,792	45,447	189,580	28,000	0	161,580
Prairie	12,315	12,315	0	0	49,219	8,400	0	40,819
Mountain grasslands	104,176	99,102	5,074	0	80,800	67,800	13,000	0
Desert grasslands	98,770	48,510	50,260	0	228,000	87,000	141,000	0
Wet grasslands	474,358	0	460,886	13,472	6,345	0	440	5,905
Desert	30,243	0	30,243	0	24,000	24,000	0	0
Alpine	2,877,902	2,877,972	0	0	2,381,358	1,273,645	1,107,713	0
Total	3,730,253	3,037,899	633,435	58,919	2,959,302	1,488,845	1,262,153	208,304
Shrublands:								
Sagebrush	163,707	118,357	13,000	32,350	1,772,689	385,920	86,000	1,300,769
Desert shrub	954,094	222,807	731,289	0	3,768,413	60,900	2,071,882	1,635,631
Southwestern shrubsteppe	149,929	30,046	79,975	39,908	511,250	5,000	506,250	0
Total	1,267,730	371,210	824,262	72,258	6,052,352	451,820	2,664,132	2,936,400
Total, range land	4,997,983	3,409,109	1,457,697	131,177	9,011,654	1,940,665	3,926,285	3,144,704
Total, forest and range land	18,757,101	[2] 15,269,135	[3] 2,832,940	655,026	26,155,101	12,547,135	10,222,501	3,385,457

[1]Administration endorsement is a position favoring the addition of land area to the National Wilderness Preservation System that reflects the support recommendation of the White House, Office of Management and Budget, and the Department of Agriculture and the Department of Interior.

[2]Includes 12,000 acres of Bureau of Land Management lands adjacent to National Park Service lands.

[3]Includes 113 acres of Bureau of Land Management lands adjacent to National Park Service lands.

in capacity, it is clear that some wildernesses are overused, while others could accommodate more use, especially with effective management.

The most heavily visited wildernesses are those located relatively close to large population centers. Visitor surveys and analyses of visitor permits show that, although some visitors come from the most distant corners of the country, most are within a few hundred miles of their homes. For example, most National Forest wildernesses in Montana draw about three-fourths of their visitors from within Montana. The Boundary Waters Canoe Area in Minnesota receives about two-thirds of its use from Minnesotans. Similarly, only about 5 percent of the National Forest wilderness visitors in California are from other States.

Recreational use is also very unevenly distributed within most individual wildernesses. A small proportion of access points and travel routes usually accounts for most use. For instance, in several wilderness studies, it was found that about half of all travel was concentrated on only one-tenth of the trail system. This poses a management challenge — to try to redistribute use more in keeping with area capacity.

The need for intensified management of visitor use is greatest in the heavily used wildernesses. Some National Park wildernesses and a half dozen National Forest wildernesses have some form of limitation on use. In other areas, managers will probably be forced to consider limiting use, although alternative actions to inform and educate visitors might shift use patterns and improve wilderness skills enough to reduce impacts and avoid or postpone these controls. Research indicates that most visitors, even in heavily used wildernesses, consider a reasonable degree of solitude to be an important wilderness characteristic and support controls on use when needed.[50] However, studies of wilderness visitors suggest that a substantial proportion, perhaps one-fourth to one-half of those who now visit wilderness, would find the recreation opportunities they are seeking as well or better in a nonwilderness, roadless area.

Recreational demand for wilderness — The accuracy of recreational use estimates is generally low and any analysis of demand must be cautious. However, based on reported use figures, recreational use in wilderness has outpaced the overall rate of growth for outdoor recreation in other areas since the first National Forest recreation estimates were released over 30 years ago. Total visits to National Forest wilderness have increased about fifteenfold since World War II, and National Park roadless areas have had similarly large increases. However, the annual rate of growth has been falling. Prior to 1960, the annual average increase in use of National Forest wildernesses and primitive areas was 15 percent — about twice the 7 percent average annual increase since 1960.

The character of wilderness recreation use has also been shifting. Backpacking, a popular family activity, has surpassed horseback riding in growth. Similarly, in the Boundary Waters Canoe Area, visitors who paddle canoes have increased faster than those who use outboard motors on boats and canoes. The proportion of visitors who go on do-it-yourself trips, in contrast to outfitted and guided trips, has grown to a majority — usually a very large majority — everywhere data are available. This is especially true in wildernesses in the East, where few visitors go with guides and outfitters.

"Wilderness areas must have outstanding opportunities for solitude" . . . — The Wilderness Act.

[50] Fazio, James R., and Douglas L. Gilbert. Mandatory wilderness permits: Some indications of success. J. For. 72(12):753-756. 1974; Hay, Edwards. Wilderness experiment: It's working. Am. For. 80(12): No. 2629. 1974; Stankey, George H. Visitor perception of wilderness recreation carrying capacity. USDA For. Serv. Res. Pap. INT-142, 619. Intermt. For. and Range Exp. Sta., Ogden, Utah. 1973: Taylor, Ronald B. No vacancy in the wilderness. Sierra Club Bull. 57(1):58. 1972.

Research has shown that wilderness visitors are overwhelmingly urban.[51] In addition, research shows that (1) wilderness visitors have high education levels, (2) most are white-collar workers, primarily in the social service and educational occupations, and (3) they are somewhat above average in income. Young adults are the most common visitors, although children and older adults are well represented. Although this youthful segment of the population has grown enormously in the last 30 years, it will grow more slowly in the decades immediately ahead and eventually decline at a proportion relative to older persons.[52]

Considering the various factors affecting demand, such as population, income, and education, it is estimated that recreational use of wilderness will continue to grow in future decades, although the rate of that growth will decrease. If no acreage is added to the National Wilderness Preservation System, its recreational use is expected to grow approximately 2 percent each year for the next several decades.[53] Larger increases are expected, however, if significant acreage is added to the National Wilderness Preservation System.[54]

Nonrecreational uses of wilderness — Although recreational activities are the most common uses of wilderness, other wilderness and resource values have important implications for assessing demands for future wildernesses and preparing management plans for existing ones.

Several research studies have suggested that many people enjoy wilderness vicariously, rather than on-site.[55] Some of these people have made, or will make, on-site visits and value the option to visit wilderness, while others never set foot in wilderness. However, all these individuals value the existence of designated wilderness.

Other wilderness uses include scientific, educational, therapeutic, and cultural activities. For instance, ecologists, biologists, and scientists in other related fields use wilderness as a natural laboratory. The contrast between the natural wilderness ecosystems found in most other places helps scientists understand each kind of system better.[56]

Equally significant, the relatively large size of most wildernesses permits many ecological processes to work more freely and with less interference than in small Research Natural Areas. This is particularly important for endangered species and some mammals with large ranges, such as grizzly bears and mountain lions, both of which have been studied in wilderness. In addition, wilderness serves as a potential gene pool for indigenous species of plants and animals.

Educational use is another input of the wilderness use. Specific data on this activity are unavailable, but it clearly is substantial and growing, enough so that it may be a significant source of use pressures in a few places. A study of the use of wilderness by seven educational organizations in the Pacific Northwest estimated 13,000 recreation visitor days of educational use of eight wildernesses in Washington and Oregon.[57] This accounted for about 5 percent of all use of these areas.

Other uses are part educational and part therapeutic. For example, Oregon mental hospital patients have been taken on wilderness trips with impressive success in patient improvement. Several studies have shown that the isolation and challenge of a wilderness setting have beneficial effects on delinquent or disturbed young people.[58]

In addition, other activities may appear to some to be inconsistent with the special qualities of wilderness, but take place in wilderness because of special provisions of the Wilderness Act of 1964. For example, the Wilderness Act permits the staking of mining claims until the end of 1983. However, presently only a few small mines are in operation within the Wilder-

[51] Hendee, John C., George H. Stankey, and Robert C. Lucas. Wilderness management. USDA For. Serv. Misc. Publ. No. 1365. Washington, D.C. (see ch. 13). 1978.

[52] Marcin, Thomas C., and David W. Lime, our aging population structure: What will it mean for future outdoor recreation use? p. 42-53. *In* Proc. of the Nat. Symp. on the Econ. of Outdoor Recreation, New Orleans, Nov. 11-13, 1974. Comp by Jay M. Hughes, and R. Duane Lloyd. Gen. Tech. Rep. WO-2. 1977.

[53] Jungst, Steven E. projecting future use of the National Forest Wilderness System. Iowa State University, Doctoral dissertation, 1978.

[54] *Ibid.*

[55] Fisher, Anthony C., John V. Krutilla and Charles J. Cicchetti. The economics of environmental preservation: a theoretical and empirical analysis. Am. Econ. Rev. 62(4):605-619. 1972: and Tombaugh, Larry W., External benefits of natural environments. Recreation Symp. Proc. USDA For. Serv., Northeast. For. and Range Exp. Sta., Upper Darby, Pa. 1971: and Cicchetti, Charles J., and A. Myrick Freeman III. Option demand and consumer surplus: further comment. Q. J. Econ. vol. 85, p. 528-539. 1971.

[56] Craighead, John J., Joel R. Verney, and Frank C. Craighead. A population analysis of the Yellowstone grizzly bears. Mont. For. and Conserv. Exp. Sta., School of Forestry, Univ. of Montana. Bull. No. 40. 1974; and Hornocker, Maurice G. Mountain lion. Naturalist. 22(3):27-32. 1971.

[57] Dick, R. J., Oltremari, D. Shepard, and A. Wilcox. Wilderness as a classroom — a preliminary report. (Unpbl. rep. on file at Pac. Northwest. For. and Range Exp. Sta., Seattle, Wash.) 1972.

[58] Thorstenson, Clark T., and Richard A. Heaps. Outdoor survival and its implications for rehabilitation. Therapeutic Recreation J. 6(4):16-161, 185. 1972; Kaplan, Rachel. Some psychological benefits of an outdoor challenge program. Environ. and Behav. (1):101-106. 1974; and Hanson, Robert A. Outdoor challenge and mental health. Naturalist, 24(1):26-31. 1973.

ness System.

Similarly, livestock grazing and water storage are other activities permitted by the Wilderness Act. At present, about 200,000 animal unit months (one animal unit month is equal to one cow or five sheep for 1 month) of livestock grazing are taking place in National Forest wildernesses. Also, there are a number of small reservoirs for irrigation or streamflow regulation built before passage of the Wilderness Act.

While it is not feasible to quantify demands for nonrecreational uses and activities of wilderness in any meaningful way, demands for most of these uses, as for recreation, seem likely to increase in the decades immediately ahead. A 1977 poll by Opinion Research Corporation of Princeton, N.J., indicates strong public support for the National Wilderness Preservation System, although interviewees were not always clear about what is a wilderness.[59] The survey, sponsored by the American Forest Institute and National Forest Products Association, found that only 7 percent of the 2,049 individuals questioned said there is "too much" wilderness. Thirty-two percent said there is "too little," while 46 percent said the current amount of wilderness is about right.

Opportunities for Meeting Future Demands for Wilderness

It is probably unrealistic to consider, as some suggest, that all currently undeveloped lands should be set aside as wilderness to preserve future options. There are, however, a number of opportunities for increasing the size and improving the management of the National Wilderness Preservation System.

Additional units — As of July 1, 1979, Congress was considering 320 Administration-endorsed proposals covering 26.1 million acres for inclusion in the Wilderness System in the contiguous United States (table 3.13). Of these proposals, 271 with a total area of 12.5 million acres were National Forest lands; 23 proposals, with an area of 10.2 million acres, were National Park System lands; the remaining 26 proposals involved 3.4 million acres of lands administered by the Fish and Wildlife Service.

These proposals have resulted from a series of studies by Federal land management agencies of their roadless or undeveloped lands. For instance, the Forest Service recently conducted a nationwide study, the Roadless Area Review and Evaluation (RARE II).[60] The purpose of this study was to: (1) Recommend to Congress roadless areas that should be designated as wilderness to help round out the National Wilderness Preservation System, (2) Determine roadless areas that should be made immediately available to nonwilderness uses, (3) Identify areas that require further study. Over 2,600 roadless areas, covering 62 million acres and located in 37 States and Puerto Rico were evaluated by the Forest Service. An evaluation procedure was used which incorporates public response received on the Draft Environmental Statement, the determination of National, Regional, and local needs for goods and services, and pertinent legislation and administrative direction. On the basis of these criteria, about 9.9 million acres were proposed by the President for inclusion in the National Wilderness Preservation System in the lower 48 States. The largest chunks of land being proposed for wilderness are 2.2 million acres in Idaho and 2 million acres in Colorado. Almost 1 million acres have been proposed in California and about 700,000 in Wyoming. In addition, another 10.6 million acres will be studied for possible inclusion in the system.

In addition to the proposals before Congress, Federal land management agencies are continuing to review the roadless or undeveloped lands for their potential to be included in the National Wilderness Preservation System. In particular, the Bureau of Land Management has considerable land that has potential for wilderness designation. The Bureau estimates that over 120 million acres of the land it administers are roadless and undeveloped. Over half of these lands are located in Alaska with the remainder in other western States. These roadless and undeveloped lands will be studied for possible inclusion in the National Wilderness Preservation System as required by the Federal Land Policy and Management Act of 1976. Presently, the Bureau of Land Management is studying 56 million acres in the 11 western States to determine whether wilderness characteristics exist and if they should become wilderness study areas. Six million acres in the California Desert Conservation Areas already have undergone intensive study.

Congress also is reviewing lands in Alaska for possible wilderness classification. Although the 94th and 95th Congress failed to complete the Alaska lands legislation, it is expected to be taken up again in the 96th Congress. Proposals for wilderness in Alaska vary. The Administration's recommendations to the Congress in 1979 were for 50 million acres of wilderness in Alaska of which 30.8 million acres would be in

[59] Opinion Research Corporation, Caravan Survey. The public's participation in wilderness areas. Opinion Res. Corp., Caravan Surveys, Princeton, N.J. 115 p. 1977.

[60] U.S. Department of Agriculture, For. Serv. Draft environmental statement. Roadless areas review and evaluation, Washington, D.C., June 1978. 112 p.

new or existing National Parks, 13 million acres would be in new or existing National Wildlife Refuges, and 6.2 million would be in existing and additions to the Chugach and Tongass National Forests. During the 96th Congress, the House passed a bill designating approximately 67 million acres of wilderness including 6.4 million acres in National Forests. The Senate committee on Energy and Natural Resources also is considering a bill which calls for the classification of about 35 million acres (including 3.9 million acres of National Forest lands and 1.4 million acres in a National Park Preserve) as wilderness. Judging from the proposals considered by the 96th Congress, it is likely that a large proportion of the National Wilderness Preservation System will be located in Alaska.

State, local governments, and private lands constitute another potential source of wilderness. Nine States throughout the Nation have established wilderness systems within their boundaries, and other public lands also have potential for wilderness designation. A noteworthy example is New York State whose 16 areas total approximately 1 million acres. Additional public units, together with such lands as the "pocket" wildernesses established by Bowaters Paper Corporation in Tennessee, could provide important protection for the Nation's wilderness resource.

Opportunities to improve wilderness management and planning — In addition to increasing the size of the wilderness resource, more indirect but nonetheless effective efforts are being made to increase the quantity and quality of wilderness experiences. One important opportunity is improved coordination and management of recreation and other uses in established wildernesses. By considering the particular characteristics of an area and its specific problems or conflicts, management plans are helping to achieve a balance between consistent policy application and responsiveness to individual area differences. In particular, a recreational carrying capacity — the number of recreationists an area can support without unacceptable change in the wilderness resource and the recreation experiences it provides — needs to be established for each unit. Actions to maintain visitation levels at or below that capacity can help in ensuring resource protection and in providing quality wilderness opportunities. For instance, trailhead management at or near the wilderness boundary can serve both the visitor and resource. Establishing new trailheads, closing others, and coordinating all trailheads can be aids to successful wilderness management. Previous neglect of this opportunity has caused some of the present user distribution problems.

Wilderness areas and wilderness use must be actively managed if the full wilderness recreation potential of the land is to be attained.

Improved coordination of wilderness planning with other resource planning efforts is also helping to facilitate effective management. Many of the most effective management techniques are those which are applied outside the wilderness rather than within it, stressing the importance of coordinated planning. For instance, an opportunity for maintaining an enduring wilderness resource is to make quality recreational experiences available on nonwilderness lands. Fishing might be equally enjoyable in a dispersed recreation area managed for this purpose but lacking such wilderness attributes as nonmotorized travel, little resource modification, and low-density use. Efforts are currently being made to develop and apply a planning technology — based on the concept of an outdoor recreation opportunity spectrum — which will serve to promote this broader range of alternative recreation opportunities. That broader range of opportunities, in turn, could indirectly help to ease the growing use pressures on wildernesses.

Opportunities to increase visitor information and education efforts — Another important opportunity for enhancing the management of the wilderness resource is providing improved information and education programs for the public. Increased efforts to promote visitor understanding and cooperation through education could help reduce the need for control of public recreation in many wildernesses. Before prospective wilderness visitors enter the wil-

derness, they could be instructed on the purpose and value of wilderness, the proper way to use it, and any rules and regulations regarding its use. Information for visitors could be made available through environmental education programs, the distribution of booklets and pamphlets, the news media, and administration of the permit system where in effect.

There is also a need for more seasonal wilderness rangers to help inform and assist visitors once they are inside wildernesses. Seasonal rangers now employed perform a variety of functions, including collection of resource data for wilderness management planning, cleanup work, fire suppression, wilderness regulation enforcement, and sign, trail and bridge maintenance. More of these seasonal employees could increase management effectiveness and help inform the public in a manner which perpetuates wilderness values.

Research opportunities—The ability to make sound, effective planning and management decisions concerning the wilderness resource will continue to improve as more is learned about how the wilderness resource is affected by use and management activities. Managers need to understand more about the wilderness resource, the people using it, and the impacts of use on the resource if management is to meet future social demands while maintaining the ecological integrity of existing units. Greater understanding of the recreation experiences which wilderness provides can be gained from visitor studies that utilize the principles and concepts of the social sciences. In particular, current efforts to gather knowledge of visitor satisfactions and benefits will enhance management effectiveness and aid in the development of improved techniques for resource inventory and visitor management.

The determination of baseline resource conditions and development of measures to monitor impacts of use on the resource needs further development to help maintain the quality of the wilderness. For instance, further information, including a better understanding of the effects of wilderness use on water and air quality, wildlife behavior, human sanitation, and basic ecological conditions and processes, is also needed for the determination of carrying capacities.

Finally, research is being conducted that involves the development of criteria and guidelines to aid managers in making decisions. Inventory systems that provide information on resource attributes can be useful in allocating roadless lands to wilderness. Improved analytical frameworks within which the consequences or trade-offs of alternative management directions regarding roadless lands can be accurately portrayed would also be useful.

Chapter 4. — Wildlife and Fish

This chapter describes the current and likely future status of forest- and range-related wildlife and fish resources and ways in which those resources can be improved. The approach is to describe (1) current and prospective market, social, and ecological demands for the resources; (2) extent to which supplies may meet those demands; (3) implications of imbalances between demands and supplies; (4) most significant problems in the management of the resources; and (5) broad opportunities to enhance wildlife and fish resources.

The future of wildlife and fish resources depends directly on the management and use of lands and waters. Decisions regarding all resources — including the timber, range, water, and outdoor recreational resources discussed elsewhere in this report — will be critical to the future welfare of wildlife and fish.

Ecological systems are dynamic and changes in species occurrence and populations are to be expected. Such changes usually reflect changes in the condition of the land and water base. In some instances, changes in animal populations have been viewed as reflections of changes in the Nation's environmental health or quality of life.[1] In any event, public concerns about the values of wildlife and fish and of many other components of the natural world have risen dramatically over the last few decades. This is reflected in the passage of laws intended to insure the maintenance and enlightened management of these resources, increases in membership of wildlife interest groups, and widespread public interest in both public and private decisions affecting wildlife and fish.

The following pages first provide a brief overview of the wildlife and fish resources of the Nation. The values ascribed to these resources and the demands placed on them are defined and compared to likely future supplies as a basis for general conclusions about the extent to which desires for wildlife and fish values might be realized. Finally, opportunities to resolve broad problems are defined in terms of habitat and population manipulations, regulations and enhancement of uses, cooperative efforts to enhance the condition of private lands, and the generation of new information through research.

A Brief Overview of the Resource

The 1.7 billion acres of forest and range lands and associated waters of the United States contain an enormous variety of wildlife and fish, ranging from tropical species in the Caribbean and Pacific Islands to caribou above the Arctic Circle to songbirds distributed throughout the Nation. The resident and common migrant vertebrate species and major subspecies directly associated with forest and range lands, or directly influenced by changes on these lands, include about 200 amphibians, 900 birds, 1,100 fish, 400 mammals, and 350 reptiles.[2] The distribution of these animals in the United States is indicated in figure 4.1. There are perhaps six or eight times as many species of invertebrates that are also distributed across the Nation.

Many of these animals spend their lives in relatively small areas, such as in or near ponds or forest clearings. In contrast, many of the birds range widely over several continents during their life cycles and are true international resources. The anadromous salmon of the Northwest spend their early lives in fresh water as far inland as Idaho and their maturing years in the ocean, returning inland to spawn and die. They, too, transcend national boundaries. Other animals, such as elk, migrate on a more local basis, moving with the seasons from summering to wintering areas. Still other species, such as the California condor, travel widely each day in search of food.

As described in the Forest and Range Lands chapter, the Nation's land base is subdivided into forest ecosystems (defined on the basis of the existing dominant timber type) and range ecosystems (defined on the basis of potential vegetation). Of the resident and common migrant vertebrate species associated with forest and range lands, about half are found in both forest and range ecosystems. Slightly more than a third are found only in forest ecosystems and the remainder are found only in range ecosystems (table 4.1).

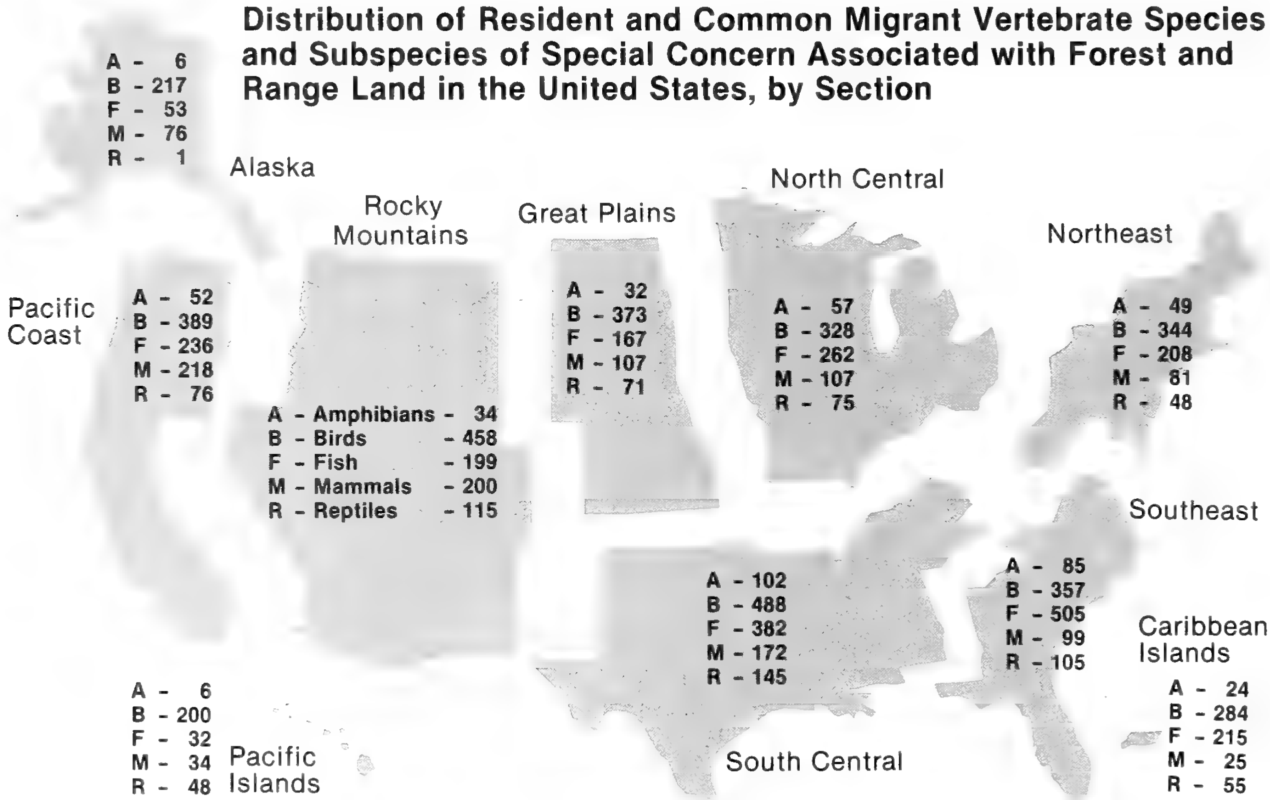
Wildlife and fish are unique resources with respect to ownership and regulation. British common law,

[1] See, for example, "10 year EQ Trend" printed annually in the February issue of National Wildlife Magazine.

[2] These numbers and all other data in this chapter for which an alternative citation is not provided have been assembled by the Forest Service in cooperation with other Federal agencies and the States, Territories, and Possessions. Descriptions, rationales, the most promising uses, and the availability of the data base are given in Schweitzer, D. L., C. T. Cushwa, and T. W. Hoekstra. The 1979 National assessment of wildlife and fish: a progress report. *In* Trans. No. Amer. Wildl. and Nat. Res. Conf. 43:266273. 1978. Included are data concerning all resident and common migrant vertebrate species found on forest or range lands or in the associated waters or that are directly influenced by the management of those lands and waters. In addition, vertebrate subspecies and invertebrates are included if they are (1) listed by the Federal or a State government as endangered or threatened by extinction, (2) known or likely to be particularly sensitive to the management of those lands and waters, (3) recreationally important, or (4) commercially important. A partial critique of these data is contained in Hoekstra, T. W., D. L. Schweitzer, C. T. Cushwa, S. H. Anderson, and R. B. Barnes. Preliminary evaluation of a national wildlife and fish data base. *In* Trans. No. Amer. Wildl. and Nat. Res. Conf. 44:380-391. 1979.

Figure 4.1

Distribution of Resident and Common Migrant Vertebrate Species and Subspecies of Special Concern Associated with Forest and Range Land in the United States, by Section



which stated that wildlife was held in trust by the king in his role as sovereign, was the basis for U.S. law. Each State retained its sovereign rights except in those instances where particular rights were explicitly granted to the Federal government by the Constitution.[3] At first this philosophy was accepted as giving to the States essentially full control over wild animals. However, the Federal role has been undergoing a redefinition and expansion, at least since the late 1800's. The constitutional basis for the Federal role is found in its treaty making, property, and commerce powers.

In general, private landowners have little legal standing in the ownership and regulation of wild animals. Like the Federal land managing agencies, they can regulate the use of animals by regulating access to their properties. A series of Federal court cases is now determining the extent to which Native Americans are a special case and do, in fact, have property rights in these resources.

[3] Bean, M. J. The evolution of national wildlife law. Council on Environmental Quality. Washington, D.C. 485 p. 1977.

Demands for Wildlife and Fish

Demands for wildlife and fish reflect the interest of people in the many types of values associated with those resources. For discussion purposes, these values and demands can be sorted into three partially overlapping categories: those associated with market products, with social experiences, and with ecological perceptions (table 4.2).

Market demands are those centered on capturing the market values generated by the sale or barter of wildlife (e.g., furs) and fish (food) products. The extent or intensity of demand for these products is usually measured by market prices and quantities sold or bartered. Those wildlife and fish products that are not sold or bartered but are substitutes for products that would otherwise be purchased — as where sport hunters eat venison rather than beef — also have "market-equivalent" values.

Social demands are defined as demands for experiences that require wildlife and fish; included are demands for hunting, fishing, and wildlife observa-

Table 4.1 — *Numbers of resident and common migrant vertebrate species and subspecies of special concern found in forest and range ecosystems in the United States, by section and category of species*[1]

Category	Total U.S.	North-east	North Central	South-east	South Central	Great Plains	Rocky Mountains	Pacific Coast	Alaska	Pacific Islands	Caribbean Islands
All vertebrates:											
Amphibians	199	49	57	85	102	32	34	52	6	6	24
Birds	904	344	328	357	488	373	458	389	217	200	284
Fish	1067	208	262	505	382	167	199	236	53	32	215
Mammals	408	81	107	99	172	107	200	218	76	34	25
Reptiles	349	48	75	105	145	71	115	76	1	48	55
Total	2927	730	829	1151	1289	750	1006	971	353	320	603
Vertebrates in forest ecosystem:											
Amphibians	180	49	56	85	85	30	28	45	6	6	24
Birds	843	344	325	336	384	343	424	308	198	192	284
Fish	1019	208	262	505	351	160	141	209	44	32	215
Mammals	325	81	98	95	109	96	145	167	60	31	25
Reptiles	282	48	74	97	112	64	65	33	1	47	55
Total	2649	730	815	1118	1041	693	803	762	309	308	603
Vertebrates in range ecosystem:											
Amphibians	116	0	17	39	53	23	31	45	2	3	0
Birds	667	0	203	207	477	350	438	368	176	73	0
Fish	410	0	70	81	176	134	179	129	51	0	0
Mammals	342	0	63	48	144	92	189	196	64	17	0
Reptiles	230	0	32	67	114	64	109	75	0	8	0
Total	1765	0	385	442	964	663	964	813	293	101	0

[1] Subspecies of special concern are: those listed by the Federal or a State government as endangered or threatened, those judged sensitive to land or water management practices, and those of commercial or recreational importance.

Source: Schweitzer, D. L., D. T. Cushwa, and T. W. Hoekstra. The 1979 National assessment of wildlife and fish: a progress report. *In* Trans. N. Am. Wildlife and Nat. Res. Conf. 43-266-273. 1978.

Table 4.2 — *Categories of wildlife and fish values and common evidence of demand*

Category of values	Brief description	Common evidence of demand
Market products	Products produced from wildlife and fish that are exchanged or serve as income supplements; includes commodities such as wild furs and canned salmon and other meat and fish that are consumed, regardless of the principal reason for harvesting.	Numbers of units of products purchased or consumed. Market prices or costs of harvest.
Social experiences	Experiences having wildlife and fish as central focus; includes hunting, fishing, and nonconsumptive recreational activities as well as cultural activities dependent upon wildlife and fish; includes contribution of commercial and recreational use of wildlife and fish to maintenance of lifestyle.	Numbers of individuals participating in experience. Actual expenditures for licenses, equipment, and travel. Estimates of willingness to pay for recreational experiences based on questionnaires.
Ecological perceptions	Perceptions that wildlife and fish are important for other than economic or social reasons; includes belief in protection of individual species and communities of species and "ecological integrity."	Numbers of people belonging to environmental organization. Laws, treaties.

tion. Common evidence of the extent of these demands includes the numbers of participants and the dollars spent to participate. In addition to providing a basis or focus for recreational experiences, wildlife and fish occasionally play a critical role in the cultural life of particular subgroups; that role is also included here as a social value.

A third group of demands is that focused on ecological or environmental values. While such demands and values are difficult to precisely define, they are nevertheless real. Ecological demands exist because people believe that wildlife and fish have other than direct market and social values. Such a perception might have a purely philosophical basis, as when wild animals are thought to have an absolute right to exist, or it might be quite pragmatic, as when wild species are thought to provide information that will be of practical importance to people. The clearest evidence of these demands are laws such as the Endangered Species Act. Changes in the numbers of people belonging to organizations that express concerns for the preservation or wise use of wildlife and fish probably are also related to changes in ecological demands.

Our ability to measure the extent of demands is greatest for products that are sold in commercial markets. Where appropriate data have been compiled, as for timber products, it is possible to define the quantities sold and likely to be sold at alternative prices — to determine from empirical evidence at least the dollar values that purchasers place on the products.

Although available information suggests that consumers of recreational experiences generally value those experiences more highly than is reflected by the numbers of dollars they spend, there is little agreement on how such information can be translated into actual-dollar-spent equivalents.[4]

Those who are concerned with one category of value often given weight to others; a focus on market values does not rule out an appreciation of social or ecological values. Indeed, there is evidence that, as knowledge of wildlife and fish resources increases, so does the individual's appreciation of all kinds of values. Similarly, many wild species are perceived to have all of these values. Given the previous definitions, every species has some ecological value.

[4] Most commonly, the value of recreational experiences to users is estimated by asking them what they would do or pay under certain circumstances. Rationales and methodologies are summarized in Dwyer, J. F., F. R. Kelly, and M. D. Bower. Improved procedures for valuation of the contribution of recreation to rational economic development. Res. Rep. 128, Water Resources Center, Univ. Illinois. Urbana. 1977.

Demands for Market Products

There are strong worldwide commercial markets for the salmon of the Pacific Northwest and Alaska and a strong European demand for the furs of mammals that are trapped throughout the United States. The fish provide a livelihood for substantial numbers of fishermen, and trapping supplements the income of numerous (mostly rural) participants.

Commercial fishing. — The most direct reflection of the market demand for salmon is its selling price, which has risen more quickly than the average price for all fish since the early 1970's. The United States value at dockside of commercial landings of Pacific salmon reached $116 million in 1975 and $196 million in 1976:[5]

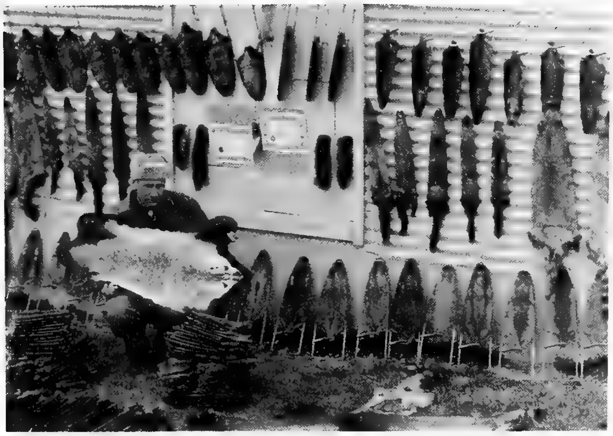
Dockside value of salmon

Species	*Total price paid*		*Price per pound*	
	1975	*1976*	1975	1976
	Million dollars		*Dollars*	
Chinook	29	51	0.91	1.49
Chum	16	21	.48	.59
Pink	20	28	.35	.29
Sockeye	30	21	.57	.62
Coho	21	45	.57	1.13
All species	116	196	.57	.63

Salmon are processed for canning or for fresh, frozen, or specialty products. This processing adds significantly to the income and employment generated by salmon. In 1977, salmon fishermen in Alaska received $166 million for the fish while the value of the salmon after processing was about $420 million.

Domestic demand for edible fishery products increased by more than half from 1967 to 1976 because of increasing per capita consumption and a continuing growth in population. During the same years, domestic landings increased by only 17 percent. As a consequence, in 1976 nearly two-thirds of the fishery products consumed in the United States were imported at a cost of about $1,861 million. Salmon products have played an important role in offsetting part of this cost through exports annually valued at about $100 million in the mid-1970's. From 1973 through 1977, France and Japan together purchased more than half of the total exports.

[5] U.S. Department of Commerce, National Marine Fisheries Service. Fisheries of the United States, 1976. Current Fishery Statistics No. 7200. Washington, D.C. 96 p. 1977.




Commercial fishing and trapping provide livelihoods to some Americans and supplement the incomes of many others.

Fur production. — Those mammals collectively called furbearers are both raised on fur farms for eventual harvesting and trapped in the wild. The numbers of farms and trappers have varied with the market price of furs. Currently, slightly more than half of all furs are harvested by trappers.

Fur production flourished in the United States until the late 1940's when a decrease in demand for fur coats and low pelt prices sharply reduced production. By 1970, demand had largely recovered, and from 1970 to 1976 both prices and harvests increased substantially. Pelt prices more than doubled for badger, bobcat, coyote, fisher, fox, lynx, opossum, raccoon, wolf, and wolverine in this period.[6]

There is a strong international trade in furs. Throughout the 1960's the United States was a net importer of furs; since 1972, the country has been a net exporter. In 1977 about three-quarters of all furs harvested were exported; these were worth $208 million, while imported furs were worth about $122 million.

If recent trends in domestic and international fashions continue, there will continue to be a strong demand for furs from the United States. This is especially true in light of recent restrictions on the international trade in furs of spotted cats, which traditionally had been supplied primarily by African and South American countries.

[6] Demas, E. F., and D. Pursley (eds.). North American furbearers: their management, research, and harvest status in 1976. International Assoc. Fish and Wildlife Agencies, Univ. Maryland Press, College Park. 1978. Prices for furs have continued to increase since these data were compiled. The authors note that some unknown portion of the apparent increases in the value of furs is due to more comprehensive and more accurate recordkeeping.

Wildlife and fish as food. — Many wild animals that are commonly consumed, such as ducks and deer, are sought by recreationists. Many other species, such as muskrats and raccoons, are appreciated by relatively small groups. In addition, nearly all game fish are considered edible. Hunters and fishermen realize market-equivalent dollar values when they consume wild animals.

Several estimates have been made of these market-equivalent values. For example, from 1969 through 1973 the annual recreational harvest of deer averaged somewhat more than 2 million animals or about 106 million pounds of boneless meat. This venison was worth more than $100 million to hunters at prevailing local prices of premium grade ground beef. In 1974 and 1975, the market-equivalent value of the annual harvest increased to about $134 million.[7] Similarly, it has been estimated that the 1975 freshwater sport fish catch of 829 million pounds was worth $1.3 billion.[8]

While such values are important to recreationists, they are critical to subsistence hunters and fishermen for whom wild animals are a primary source of food. In the mid-1970's, for example, the harvest of salmon in Alaska for subsistence purposes totaled about 3 million pounds annually. Applying the average dockside price paid to commercial fishermen for salmon at that time — $0.63 per pound — yields a market-equivalent value of about $2 million. This is probably an underestimate because the harvests of

[7] Wilcox, S. W. Deer production in the United States: 1969-1973. (plus annual reports) Arizona State Univ., Tempe. 1976.

[8] Stroud, R. H. Recreational fishing. *In* Wildlife and America. H. P. Brokaw (ed.) Council on Environmental Quality. Washington, D.C. p. 53-66. 1978.

fish by subsistence users are not entirely known. Even less is known about the harvest of other animals.

A study based on partial data suggests the consumption by Alaskan natives of foods that were not sold through commercial channels in 1973 included the following:[9]

Kind of food	*Proportion of total "not-purchased" diet*	*Major components*
Mammals	49 percent	Caribou — 44 percent
		Moose, seal — 33 percent
Fish, shellfish	46 percent	Whitefish, chum and pink salmon — 54 percent
Birds	2 percent	Geese, ducks, and ptarmigan — 87 percent
Berries, greens, roots, vegetables	3 percent	

Little attention has been paid to the extent to which nonmarketed animals are sources of food. It seems likely, though, that they are an important component of the national diet. In the face of rising prices for marketed red meat, market-equivalent values will undoubtedly continue to increase.

Demands for Social Experiences

Many believe it is important to maintain the present diversity of cultures or ways of life in the United States, either because the Nation will be somehow better or stronger or simply because citizens should be able to live in the manner they choose. The right to harvest wildlife and fish is critical to maintaining some cultures. For example, the importance to Native Americans of subsistence rights to fish and wildlife has been widely recognized in the past decade.[10] Unfortunately, there are no comprehensive measures of the extent of the needs for the resources for this purpose.


Wild animals are an important source of food for natives in Alaska and Canada and in a smaller way for many hunters and fishermen.

By contrast, recreational demands for wildlife and fish have been the subject of numerous descriptive studies. Substantial sums are spent each year for professional guides, transportation, cameras, birdseed, and a host of other items related to recreational activities. The major kinds of activities for which comparable national data are available are shown in table 4.3.[11]

Fishing is the most popular consumptive activity. Because of the relative abundance of warm water habitats near population centers, the most sought-after species are those adapted to warm waters; they include panfish such as perch, black bass, catfish,

[9] Thomas, M. E., V. H. Burke, and W. C. Thomas. Some measures of food availability consumption in Alaska. Agrico Exp. Sta., Univ. Alaska, Fairbanks. Tables 6 and 7. 1976.

[10] See, for example, Federal-State Land Use Planning Commission for Alaska. Summary of the conference on taking fish and game resources to meet subsistence needs. Study 16. 19 p. memo. Anchorage. 1974.

[11] Unless noted otherwise, all descriptive data concerning recreationists and their characteristics are taken from U.S. Department of the Interior, Fish and Wildlife Service. 1975 national survey of hunting, fishing, and wildlife associated recreation (including unpublished supporting statistical data). 91 p. Washington, D.C. 1977. Due to varying definitions and sampling problems, estimates of numbers of participants vary widely among studies of this nature and are not highlighted here. The relative importance of various activities is believed to have been accurately estimated.

northern and walleye pike, and muskie. The most popular anadromous fish species in 1975 included:

Proportion of anglers	Species	Principal range
(Percent)		
40	Salmon	Chinook and coho — Alaska to California, inland to Idaho (transplanted to Great Lakes) Chum — Alaska to Oregon Pink, sockeye — Alaska to Puget Sound Atlantic — remnants in northeast; population now being re-estblished
36	Striped bass	Canada to Louisiana (transplanted to Pacific Coast and to inland States)
21	Steelhead	Alaska to California, inland to Idaho (transplanted to Great Lakes)
14	Sea-run trout	Cutthroat, Dolly Varden — Alaska to California
5	Shad	Canada to Florida (transplanted to Pacific Coast)

Most hunters do not specialize in one type of hunting. For example, 73 percent of those who hunt big game also hunt small game. Consider the following cross-tabulation of those who hunt several kinds of animals:

Of those who hunt these animals —	this proportion also hunts these: Big game	Small game	Migratory birds	Other species
		Percent		
Big game	—	73	39	29
Small game	58	—	46	34
Migratory birds	59	88	—	36
Other species	61	91	50	—

Table 4.3 — *Participation and annual expenditures in selected recreational uses of wildlife and fish in the United States, 1975*[1]

Activity	Portion of population[2]	Days per person	Annual cost per person	Average cost per person per day
	Percent	*Days*	*Dollars*	*Dollars*
All fishing	(29)			
Warmwater	22	21	188	9
Coldwater	10	13	159	12
Anadromous	4	9	158	17
Saltwater	9	13	211	17
All hunting	(11)			
Small game	9	16	104	6
Big game	7	10	196	20
Migratory birds	5	10	109	11
Clamming and crabbing	14	9	[3]	[3]
Wildlife observation	27	32	[3]	[3]
Wildlife photography	8	10	[3]	[3]

[1] Days per person and cost data rounded.
[2] Includes those at least 9 years of age who participated to any extent in 1975.
[3] Comparable national data not available.
Source: U.S. Department of the Interior, Fish and Wildlife Service. *1975 national survey of hunting, fishing and wildlife associated recreation.* (Including unpublished supporting statistical data.) Washington, D.C. 1977.

Only a third of those who fish also hunt; 90 percent of the much smaller number who hunt also fish. About half of those who go on outings specifically to observe or photograph wildlife also hunt or fish at other times. The average age of participants in all hunting and fishing activities is about 30. Less than 10 percent of the hunters and 25 to 30 percent of the anglers are women; nearly half of the participants in nonconsumptive activities are women. Average family incomes are between $10,000 and $15,000 except for saltwater anglers and nonconsumptive users, whose average incomes are slightly higher.

Future recreational demands. — Although outdoor recreation centered on wildlife and fish includes commercial operations for which there is information on market values, most that occurs on forest and range lands is available without charge or at a nominal charge determined administratively. As a result, future demands for the Nation cannot be estimated by traditional economic procedures. Instead, it is necessary to express expectations of future participation in terms of desired participation levels.

Although disparities exist among available surveys, appreciative or nonconsumptive users have increased in numbers rather substantially in the last decade. Birding appears to be continuing to increase in popularity. Wildlife photography is increasing more rapidly, but the number of photographers is so small that projecting trends is risky. On the other hand, nature and wildlife observers and memberships in

wildlife-related organizations are increasing moderately and will probably continue to grow in the near future. Although more comprehensive data collecting is undoubtedly the cause of some of the apparent increases, at the minimum, modest growth will occur over the next few decades.[12]

National projections of participation in hunting and fishing can be made with somewhat more certainty. Available data suggest there will continue to be substantial growth in the numbers of people who want to participate. This growth will continue the upward trends established during the past 30 years, during which the number of licensed hunters has doubled and the number of licensed fishermen has more than tripled. Given the opportunity to participate at an acceptable cost, within a decade there will be 20 percent more freshwater anglers and waterfowl hunters and smaller increases in the numbers of big game and small game hunters (fig. 4.2).[13]

There are significant differences in the projections of participation by region (table 4.4). The largest increases will generally be on the Pacific Coast and in the Southeast.

Demands Related to Ecological Perceptions

Ecological demands are concerned with values other than those associated with market products or social experiences. Included are demands that each species be preserved and that at least the existing variety of species be maintained throughout the Nation. The Endangered Species Act is evidence of the national demand or concern for the preservation of each species. And taken together, the total com-

[12] More, T. A. The demand for nonconsumptive wildlife uses: a review of the literature. U.S. Department of Agriculture, For. Serv. Northeastern For. and Range Exp. Sta. Tech. Rep. NE-52. 16 p. Broomall, Pa. 1979.

[13] Dyer, A. D., and W. E. Wegert. Demand analysis and projection of use for hunting and fishing opportunities. M.S. dissertation. College of Forestry and Natural Resources, Colorado State Univ. Fort Collins. 1978. These projections are essentially extrapolations to a growing population of past participation rates by age groups, as reported in the periodic national hunting and fishing surveys. Adjustments of some data were made to compensate for changes in definitions among surveys. Because many of the determinants of actual participation — such as energy availability and disposable income — were not explicitly considered, the order of magnitude of each projection is its most important characteristic.

Figure 4.2

Projections of Participation in Major Hunting and Fishing Activities Under Medium Level Population Assumptions, 1978-2030

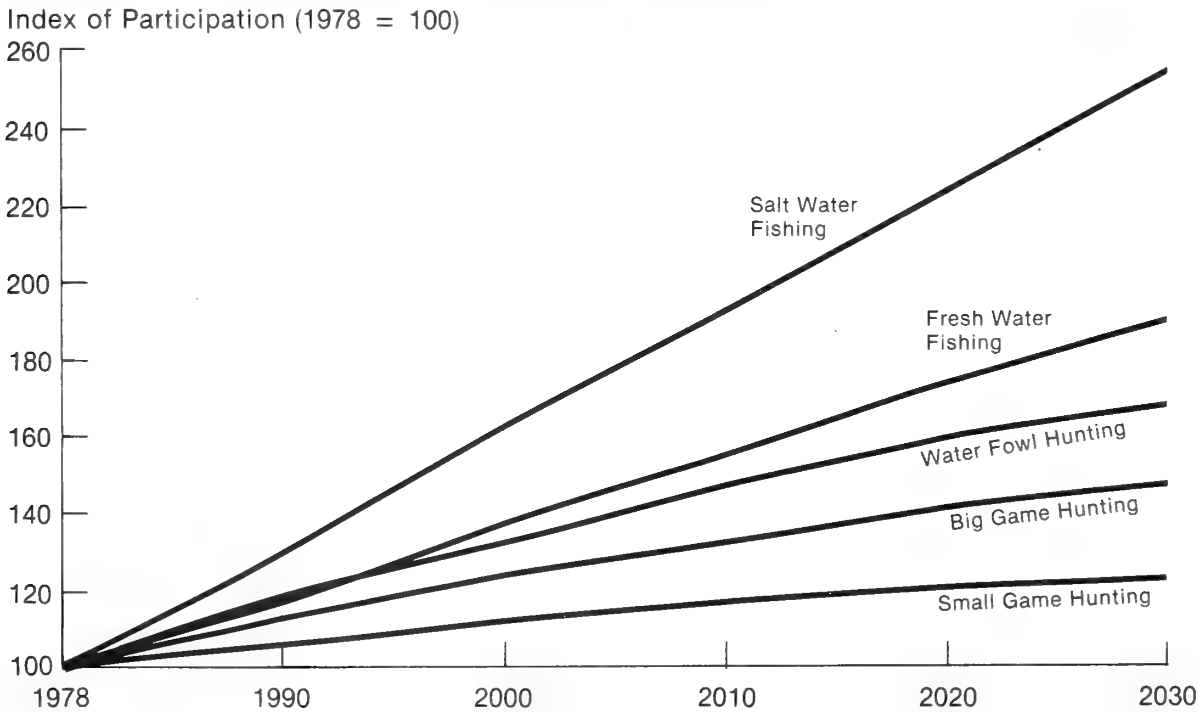


Table 4.4 — *Projections of indexes of participation (medium population level) in fishing and hunting in the contiguous States by activity and section, 1990-2030*

(1977 = 100)

Type of activity and region	Year					
	1977	1990	2000	2010	2020	2030
Population index[1]	100	112	120	127	134	139
Saltwater fishing						
Northeast	100	129	159	188	217	247
North Central	100	130	159	185	207	236
Southeast	100	130	165	198	233	265
South Central	100	128	159	189	220	251
Rocky Mountains	100	130	159	185	207	235
Great Plains	100	129	157	182	203	231
Pacific Coast	100	132	166	199	234	266
All regions	100	130	162	193	225	256
Freshwater fishing						
Northeast	100	116	134	148	261	176
North Central	100	118	138	155	172	187
Southeast	100	120	144	166	189	206
South Central	100	117	137	155	171	187
Rocky Mountains	100	119	139	161	184	201
Great Plains	100	118	138	155	171	187
Pacific Coast	100	116	140	160	179	196
All regions	100	118	139	157	174	190
Waterfowl hunting						
Northeast	100	116	125	135	141	149
North Central	100	118	132	146	158	167
Southeast	100	120	139	159	175	185
South Central	100	118	131	146	158	167
Rocky Mountains	100	120	134	148	161	169
Great Plains	100	118	132	146	158	167
Pacific Coast	100	121	137	156	170	179
All regions	100	119	133	148	160	169
Big game hunting						
Northeast	100	113	122	129	135	141
North Central	100	113	124	132	139	145
Southeast	100	115	131	144	157	163
South Central	100	113	123	131	139	145
Rocky Mountains	100	119	135	149	162	168
Great Plains	100	113	124	132	139	145
Pacific Coast	100	117	131	142	153	159
All regions	100	114	125	134	142	148
Small game hunting						
Northeast	100	106	109	112	112	115
North Central	100	106	112	117	119	122
Southeast	100	106	116	124	129	132
South Central	100	106	111	116	119	122
Rocky Mountains	100	106	129	131	138	141
Great Plains	100	106	112	117	119	122
Pacific Coast	100	106	122	130	135	134
All regions	100	106	113	118	121	124

[1] Index of projected increases in population (medium level).
Source: Dyer, A. D. and W. E. Wegert. *Demand analysis and projection of use for hunting and fishing opportunities.* M.S. dissertation, College of Forestry and Natural Resources, Colorado State University. Fort Collins. 1978

plex of Federal laws sets as a national objective the maintenance of a variety of physical conditions capable of supporting as wide a variety of species as possible.[14] The reasons behind these laws vary from a philosophical belief that preservation is morally right to a recognition of the practical value of preserving gene pools.

From the perspective of altering the physical condition of forest and range lands and associated waters, the first ecological concerns are for those species that are already in danger of extinction. The numbers of endangered or threatened species and major subspecies listed by the Federal government are shown by animal category and geographic area in the top quarter of table 4.5. By law, Federal agencies are required to try to improve the status of each until it can be removed from the list.

The second quarter of table 4.5 lists the additional numbers of species that have been placed on comparable lists by individual States. Occurrence of a species on a State list is frequently an indication that it will later appear on the Federal list.

The third quarter of the table contains the additional numbers of species judged by Forest Service wildlife biologists to be particularly "sensitive" to changes in physical conditions caused by applying standard management practices. These species have been designated as requiring particular consideration when evaluating the likely impacts of management activities on the National Forests.

The bottom part of table 4.5 shows that nearly 2,000 species and major subspecies of vertebrates and invertebrates may require some sort of special consideration in the management of our forests and rangelands.

The entire preceding discussion of demands is based on the notion that wildlife and fish have clienteles or advocates because those resources are recognized by people as having value. But given our rudimentary understanding of how ecological systems function and of the actual and potential contributions made by wild fauna, it is certainly true that there can also be actual values that are not recognized. For want of a more suitable categorization, the insistence by some that our present limited knowledge calls for a conservative approach to altering our land and water base is included here as an ecological demand.[15]

[14] Bean, M. J. The evolution of national wildlife law, *op. cit.*

[15] See Fisher, A. C. and J. V. Krutilla. Valuing long run ecological consequences and irreversibilities. J. Environ. Econ. and Manage. 1:96-108. 1974. For a discussion of American attitudes towards animals, see S. R. Kellert. Perceptions of animals in American Society. *In* Trans. No. Amer. Wildl. and Nat. Res. Conf. 41:546-553. 1976.

Table 4.5 — *Numbers of endangered, threatened and sensitive-to-management species and subspecies in the United States, by category and section, January 1979*

Category	Total U.S.	North-east	North Central	South-east	South Central	Great Plains	Rocky Mountains	Pacific Coast	Alaska	Pacific Islands	Caribbean Islands
Federally-listed endangered and threatened species[1]											
Amphibians	7	0	0	1	3	0	0	2	0	0	1
Birds	70	3	4	9	10	3	6	12	4	40	7
Fish	41	4	3	4	14	0	16	8	0	0	0
Mammals	25	4	4	7	7	2	8	7	0	3	1
Reptiles	18	0	0	5	2	0	1	4	0	0	10
Invertebrates	39	4	9	14	20	0	1	6	0	0	0
Total	200	15	20	40	56	5	32	39	4	43	19
Additional State-listed endangered and threatened species											
Amphibians	60	9	16	12	11	9	15	6	0	0	3
Birds	36	2	34	77	48	25	80	5	1	23	57
Fish	222	11	103	58	46	18	42	6	0	0	0
Mammals	9	2	19	28	6	22	43	6	5	1	2
Reptiles	88	8	33	12	11	12	31	2	0	0	10
Invertebrates	115	0	2	20	94	0	0	0	0	0	4
Total	820	32	207	207	216	86	211	25	6	24	76
Additional Forest Service-designated sensitive species											
Amphibians	73	7	8	49	45	0	5	35	4	0	0
Birds	305	109	112	212	180	45	156	197	43	36	1
Fish	261	41	32	206	220	14	55	29	8	5	0
Mammals	97	25	26	46	68	17	43	38	29	6	1
Reptiles	66	4	14	53	34	0	7	42	0	0	0
Invertebrates	58	5	0	5	5	0	1	0	32	1	9
Total	860	191	192	571	552	76	267	341	116	48	11
Cumulative total											
Amphibians	140	16	24	62	59	9	20	43	4	0	4
Birds	611	114	150	298	238	73	242	214	48	99	65
Fish	524	56	138	268	280	32	113	43	8	5	0
Mammals	221	31	49	81	81	41	94	51	34	10	4
Reptiles	172	12	47	70	47	12	39	48	0	0	20
Invertebrates	212	5	11	39	119	0	2	6	32	1	13
Total	1880	234	419	818	824	167	510	405	126	115	106

[1] This tabulation agrees with that published in the Federal Register (Vol. 44, No. 12, 1/17/79), except that eight whales have been omitted.

Source: Schweitzer, D. L., C. T. Cushwa, and T. W. Hoekstra. The 1979 National assessment of wildlife and fish: a progress report, op cit. See source note table 4.1.

The Endangered Species Act is evidence of national demand for preservation of all species of wildlife and fish.

The people especially concerned about ecological values have been quite effective since about the mid-1960's in stimulating the passage of Federal laws. Whether this trend will continue is open to debate. For example, there has been growing support to provide in law and by appropriations a greater recognition of the values of nongame wildlife. On the other hand, the original absolute requirements of the Endangered Species Act have been modified to permit conflicting resource values to be realized where that course of action is judged to be in the best interest of the Nation. As a generalization, however, developments in this country suggest that public concerns about ecological values are likely to continue to be significant.

Supplies of Wildlife and Fish and Comparisons with Demands

The major values associated with wild animals that are found on forest and range lands and the national demands for those values have been broadly described. In this section, trends in the supplies of wildlife and fish are discussed and contrasted to trends in demands so that likely future imbalances can be identified.

With some notable exceptions, the numbers of animals in wild populations are essentially unknown. As a consequence, professional judgments of resource changes over time and recorded changes in harvest levels must serve as the principal bases for discussions of trends in supplies, and only short-term projections into the future are feasible.

The information presented below on recent trends, and the prospects for the next decade, suggest that some types of demands may not be met; in fact, just maintaining present population levels of many species will be difficult.

Supply of Fish

The fish associated with forest and range lands are found in marshes, ponds, lakes, streams, estuaries, and the ocean. The total number of fish species and major subspecies and the numbers that are recreationally and commercially important are summarized in table 4.6 by type of water and geographic area.

Fifteen years ago, the Outdoor Recreation Resources Review Commission noted that the creation of fishing sites at artificial impoundments plus intensified management of natural lakes and ponds were the primary means by which future demands for freshwater fishing could be met[16] Subsequently, 3.3 million acres of reservoirs, farm ponds, and fishing lakes were constructed in the 1960's. Today, nearly half of all warmwater fishing takes place in artificially stocked impoundments or reservoirs or in association with dams (table 4.7). In roughly the same period, more than a million acres of natural fishing waters were renovated, restocked, or made newly accessible to anglers. In many instances, undesirable species were replaced with more popular fish, fertilizers were applied to stimulate food production, and nesting and rearing cover was installed.

Coldwater populations are also being supplemented with hatchery fish, though to a lesser extent than is true for warmwater fish; a quarter of all coldwater fishing is related to artificial impoundments. It is common to stock even high mountain lakes in Wildernesses in an attempt to meet the constantly growing demand for sport fishing.

The construction of millions of acres of reservoirs and ponds in recent decades has greatly benefited wildlife and been a primary means of meeting growing demands for fishing.

The story is similar for anadromous fish. In Oregon, Washington, Idaho, and California, a substantial proportion of all caught salmon are now produced in fish hatcheries. In contrast, nearly the entire Alaska salmon population is still produced naturally. In both Alaska and the Northwest, private fish hatcheries are beginning to supplement those built with State and Federal funds.

In the mid-1970's, annual harvests of Pacific salmon averaged about 40 million fish (table 4.8). Over the past 20 years, both the sports harvest and the number of recreational anglers have increased by about 10 percent. There are now about 1.3 million anglers in the Northwest and 13,000 in Alaska.

Subsistence users annually harvest about 350,000 salmon in Alaska. At least 7,000 subsistence users are known; the numbers in interior and arctic Alaska are not known.

During the last two decades, commercial harvests have varied greatly from year to year (fig. 4.3). This has been particularly true for pink and sockeye salmon, with the years from 1972 through 1975 yielding exceptionally low harvests. (In contrast, Canadian harvests of sockeye were near record high levels in 1972 and 1974.) In spite of the great fluctuations over the past two decades, no long-term increasing or decreasing trend in harvests is apparent for this

[16] Outdoor Recreation Resources Review Commission. Sport fishing — today and tomorrow. Study Rep. No. 7, 84 p. Washington, D.C. 1962.

Table 4.6 — *Numbers of fish species and major subspecies of recreational and commercial importance associated with forest and rangelands in the United States, by type of water and section*

Type of water[1]	Total U.S.	North-east	North Central	South-east	South Central	Great Plains	Rocky Mountains	Pacific Coast	Alaska	Pacific Islands	Caribbean Islands
	All species										
Marsh	289	45	88	105	32	133	104	11	10	8	35
Lake	475	113	151	228	158	158	130	100	28	17	31
River	720	195	241	383	374	156	185	132	51	28	68
Estuary	449	29	0	120	29	0	1	139	42	5	171
Ocean	460	17	0	158	24	0	0	124	31	8	185
Total	1,067	208	262	505	382	167	199	236	53	32	215
	Recreationally important species										
Marsh	208	41	42	46	19	50	71	4	5	5	25
Lake	288	95	71	79	95	57	89	56	16	11	26
River	373	130	73	106	162	53	113	62	26	16	42
Estuary	185	23	0	57	7	0	1	48	21	3	57
Ocean	195	16	0	87	3	0	0	44	15	6	63
Total	488	139	80	158	163	57	122	95	26	19	80
	Commercially important species										
Marsh	134	19	30	16	6	53	19	3	2	0	23
Lake	175	40	49	37	37	55	29	16	8	1	20
River	223	62	48	60	52	56	32	23	16	1	40
Estuary	182	17	0	54	4	0	0	57	15	0	46
Ocean	183	12	0	80	3	0	0	55	10	0	49
Total	330	65	55	108	55	56	34	64	16	1	64

[1] A given species can be found in several types of water and all species included have been judged to be directly influenced by the management of forest and/or range ecosystems. Type of water follows classification of palustrine, lacustrine, riverine, estuarine, and marine suggested by L. M. Cowardin, F. C. Golet, and E. T. LaRoe, Classification of wetlands and deep water habitats of the United States. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C., p. 100, 1977. Reservoirs and impoundments are excluded.

Source: See source note table 4.1.

Table 4.7 — *Percentages of fishing days in the United States, by species group and type of water, 1975*

Type of water	Species group: Cold-water fish	Warm water fish	Anad-romous fish	All fish
Great Lakes	5	2	11	3
Other lakes and ponds	27	31	0	28
Impoundments, reservoirs, and tailwaters	26	48	0	41
Streams and rivers	42	19	31	25
Estuaries	0	0	26	1
Saltwater	0	0	32	2
Total	100	100	100	100
Fishing days for species group as percent of total	21	74	5	100

Source: See source note table 4.3.

period.[17] The Alaskan share of the total U.S. harvest has varied from 62 percent (in 1973) to 91 percent (in 1977) and has averaged about three-quarters of the total.

About 570,000 sport anglers annually caught 1.4 million steelhead in the Northwest in the mid-1970's. A third of the land-based steelhead fishing was on the National Forests, with most of the rest split between State and private lands. State lands were most important for salmon fishing, accounting for nearly half of all land-based fishing; private land accounted for most of the rest.

[17] The greatest catches in history, of well over 600 million pounds, were taken in the middle and late 1930's. There was a continuing decrease in annual catches to an average of less than half that total during the 1950's. Department of Agricultural and Resource Economics, Oregon State Univ. Socio-economics of the Idaho, Washington, Oregon, and California coho and chinook salmon industry. Report to the Pacific Fishery Management Council. Vols. A and B. Corvallis, Oregon. 1978.

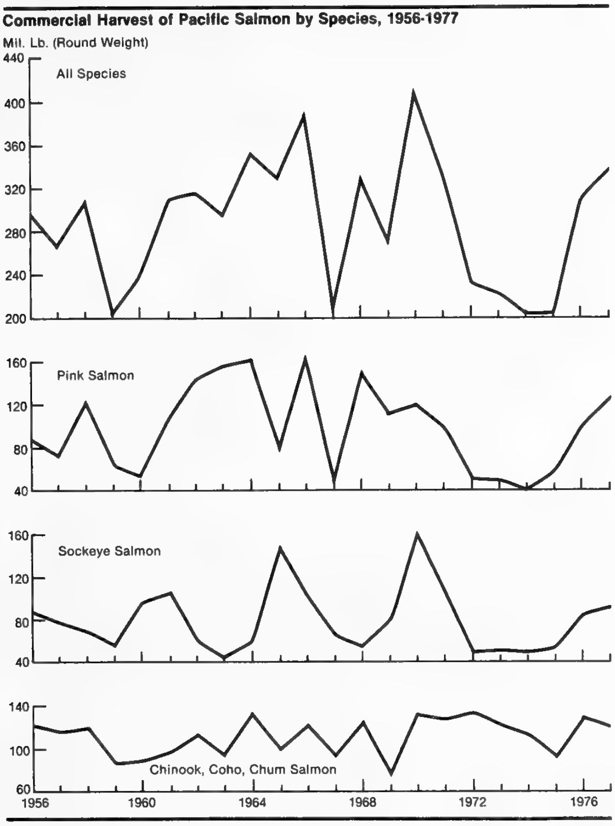
Council on Environmental Quality. 1978. Wash., D.C. p. 314. 1978.

Table 4.8 — *Average annual harvest of Pacific salmon, by species and type of harvest, mid-1970's*
(Thousands of fish)

Species	Harvest in Washington, Oregon, California, Idaho		Harvest in Alaska			
	Total harvest	Commercial harvest as percent of total	Total harvest	Commercial harvest	Recreational harvest	Subsistence harvest
Pink salmon	704	Nearly all	15,305	15,256	21	28
Sockeye salmon	2,150	Nearly all	8,246	8,053	5	188
Chum salmon	338	Nearly all	5,105	5,051	6	48
Coho salmon	3,381	60 percent	1,434	1,399	23	12
Chinook salmon	2,150	30 percent	587	507	10	70
Total	8,723	—	30,677	30,266	65	346

Note: Data derived from information supplied by individual States

Figure 4.3



In the 1950's and 60's, coho and chinook salmon were first introduced to the Great Lakes from the West Coast. Continuing stocking programs (and control of the lamprey eel) resulted in harvests in the mid-1970's of about 1.7 million sport fish annually.

As a result of the increasing demand and gradually increasing prices for fishery products, by the mid-1970's more than 130 million pounds of finfish and shellfish were raised in controlled habitats and sold for human consumption annually by the aquaculture industry in the United States. Warmwater channel catfish was the most important species, yielding about 80 million pounds of fish and over $40 million in sales. This industry now includes at least 2,000 commercial fish farmers and perhaps an additional 1,000 fee-fishing operations; it is centered in Mississippi, Louisiana, and Arkansas. Thirty million pounds of trout are sold by about 100 commercial farms and another 1,200 farms provide fish for stocking private waters; this industry is centered in Idaho and Montana. Salmon, oysters, crayfish, and shrimp are also produced in significant quantities. Although it has been estimated that a total production of 2 billion pounds is possible within two or three decades, there are major institutional, environmental, and economic problems that would have to be overcome.[18]

Supply of Furbearers

Furbearers are discussed separately from other mammals because of their significant economic values as a source of pelts for the national and international fur trade.

In 1975-76, 13 million pelts brought about $123 million at public auctions in the contiguous United States. This figure represents a sixfold increase in the value of pelts between the 1970-71 and 1975-76 seasons. The increase in value is due to both an increase in harvests, from 7 million to 13 million pelts, and increases in the values of individual furskins.

[18] Lowell, R. T. Fish culture in the United States. Science 206: 1368-72. 1979.

National Research Council. Aquaculture in the United States —constraints and opportunities. National Academy of Sciences, Washington, D.C. 123 p. 1978.

Klontz, G. W., and J. G. King. Aquaculture in Idaho and nationwide Idaho Water Resources Institute, Univ. Idaho, Moscow. 86 p. plus appendix. 1975.

In the 1975-76 season, half the pelts were muskrat; another third of the total consisted of raccoon and nutria. Raccoon accounted for 50 percent of the total value, muskrat for 18 percent, and nutria, red fox, and coyote for 6 or 7 percent each (table 4.9).

With the exception of the opossum and nutria, all the above species are widespread, occurring in at least 70 percent of the area of the Nation. The opossum is spread across perhaps half of the country, primarily in the East, and the nutria is restricted to the South Atlantic and Gulf Coasts and to the West Coast. Private lands, and especially riparian areas, provide most of the habitat for furbearers. Exceptions are Alaska, where public lands are most important, and the Rockies, where critical habitats are spread among all ownerships.[19]

The demand for furskins is governed by trends in fashions. The current, relatively high demand is expected to continue for some time. It is felt by many that existing population levels of furbearers are adequate to support demand during the next decade or so, at least for most species. However, at this time there is a particularly sharp dispute over the status of existing populations of bobcats, which are in high demand as a source of "spotted cat" furs.

[19] Sisson-Lopez, P. J., and A. T. Cringan. An analysis of the U.S. fur trade. Dep. Fishery and Wildlife Biology, Colorado State Univ., Fort Collins, Colo., 57 p. 1979.

Supply of Other Small Mammals and Upland Game Birds

This group includes hunted upland birds and small mammals other than furbearers. About 40 million rabbits and hares, squirrels, and quails, and perhaps 12 million pheasants, 3 million grouses, and 1 million partridges are harvested each year. The small game species attracting more than a million hunters each in 1975 were:[20]

Species	*Number of hunters*
	Millions
Rabbit, hare	10.2
Squirrel	8.6
Quail	6.0
Pheasant	5.9
Dove	4.7
Woodchuck, ground squirrel	3.1
Crow	2.5
Grouse	2.3

Table 4.9 — *Harvests and commercial values of pelts of furbearers sold in the contiguous States, by section, 1975-76*

Furbearer and commercial value	Northeast	North Central	Southeast	South Central	Rocky Mountains and Great Plains	Pacific Coast	Total	Proportion of commercial value
	Thousands of animals							*Percent*
Beaver	31	96	9	3	37	14	188	1
Coyote	0	36	0	30	97	13	176	6
Gray fox	28	64	21	42	6	2	163	2
Red fox	33	141	12	7	77	1	272	7
Mink	15	133	11	55	19	3	235	2
Muskrat	1,666	3,012	300	853	405	179	6,416	18
Nutria	10	0	15	1,532	0	13	1,570	7
Opossum	139	270	51	208	57	3	729	1
Raccoon	330	1,800	190	687	212	13	3,232	50
Other[1]	21	54	10	108	54	10	259	6
Total	2,273	5,606	619	3,525	964	251	13,240	100
	Millions of dollars							
Commercial value to trappers and fur-farmers	15	55	6	30	15	2	123	

[1] Includes 15 species yielding less than 100,000 pelts each.
Source: E. F. Deems, and D. Pursley (eds.). *North American furbearers: their management, research, and harvest status in 1976.* International Assoc. of Fish and Wildlife Agencies, Univ., Maryland Press, College Park, 1978.

Perhaps as many as 12 million pheasants are harvested each year.

Seventy-one percent of all small game hunting occurs on private lands (table 4.10). These lands provide most hunting opportunities even in the West, where Federal ownerships are most extensive (table 4.11).

Table 4.10 — *Percentage distribution of days hunting in the United States, by land ownership and major activity, 1975*

Ownership	All hunting	Big game hunting	Small game hunting	Migratory bird hunting[1]
Private	67	57	71	69
Federal	10	17	7	8
State	10	17	7	8
Public, unspecified	8	8	9	8
Unknown	5	3	6	4
Total	100	100	100	100

[1] Includes ducks, geese, doves, woodcock, rails, coots, and gallinules.
Source: See source note table 4.3.

As the numbers of hunters have increased over time, greater pressures have been placed on animal populations. A measure of changes in this pressure is provided by the ratios of numbers of animals to numbers of hunters. Such ratios for small mammals and upland game birds are presented in figure 4.4. Any ratio greater than 1.0 represents a time when there were more animals per hunter than was true in the mid-1970's, which is the base period for these data.[21]

For all parts of the Nation, pressures on populations of upland game birds have increased substantially during the past 20 years. By contrast, at least in the Northeast, North Central, and Pacific Coast regions, there has been little increase in pressures on small mammal populations, which seems to be due to a combination of actual increases in those populations and changes in the way the populations are estimated. The extraordinary changes in pressures in the Rocky Mountain and Great Plains sections reflect the fact that until recently small game species were hunted by relatively few recreationists.

[21] Data on the numbers of hunters and animals at the mid-point of each decade were provided by the individual States and are included in the data base cited in footnote 2. Because these data are incomplete, it was necessary to exercise considerable professional judgment to construct the ratios for groups of species and groups of States shown in figures 4.4 and 4.5. Tables 4.-1 and 4.13 were developed in a similar fashion.

Supply of Large Mammals and Turkeys

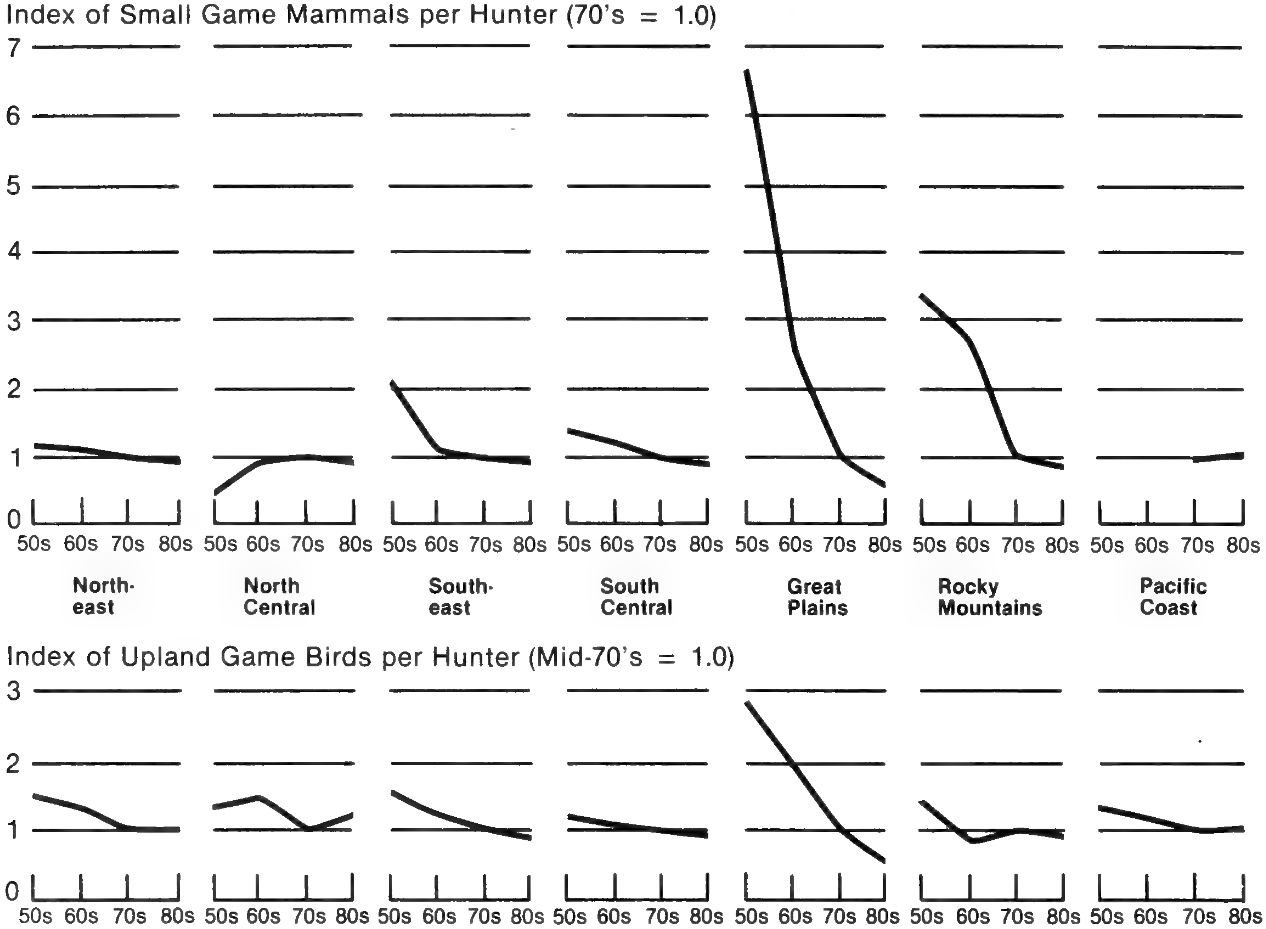
This discussion includes the big game species and, for convenience, turkeys. By far, the most widely hunted big game species in the United States is the white-tailed deer. Mule deer, turkey, elk, bear, antelope, moose, mountain sheep, mountain goat, and javelina are all regionally important species. The proportion of hunters seeking each of these species and national trends in harvest since the mid-1950's is shown in table 4.12.

With a few exceptions, these data show increasing harvests over time. Both turkey and javelina are species that have become more popular as game recently. The exceptions to these increases are generally those species that have relatively specialized habitat requirements that either are not capable of sustaining large numbers of animals or that are particularly sensitive to intrusions by man.

Changes in pressures on big game animal populations are expressed by ratios of numbers of animals to numbers of hunters in figure 4.5. Pressures have increased substantially over the past 20 years in most parts of the country. It is noteworthy that, with the exception of the South Central and Great Plains sections, State wildlife experts expect that big game populations will increase at least as fast as the number of hunters over the next 5 to 10 years. In some areas, these judgments are based on the belief that animal populations will increase substantially as the result of management and protection activities.

Figure 4.4

Numbers of Small Game Mammals[1] and Upland Game Birds Relative to Numbers of Hunters in the Contiguous United States by Section, Mid-1950's through Mid-1980's



[1]No data for Pacific Coast before 1970's; indexes exceed scale for Rocky Mountains and Great Plains before 1970's.

(This has generally been true in the past for white-tailed deer and for turkeys.) In other areas, particularly in the West, this result is based on expectations that many who would like to hunt big game will not be given that opportunity. Limits on the numbers of licenses sold will reduce the numbers of hunter-participants.

While two-thirds of all hunting takes place on private lands, the proportion for big game hunting is somewhat less because most of these species are found in relatively remote areas. The pattern of land use varies, of course, by area and by species (table 4.13). There is generally much greater dependence on private lands east of the Mississippi River.

Supply of Waterfowl

The annual harvest of ducks has fluctuated between 4 and 16 million birds in the last 20 years because of changing climatic conditions in the major breeding grounds. High duck harvests in the late 1950's and in the early and middle 1970's followed relatively wet years; low harvests in the early and late 1960's and late 1970's followed much drier conditions in the prairie pothole region (fig. 4.6).

Mallards, pintails, wood ducks, scaup, and teal are the most heavily harvested species. The distribution of harvests by species in the early 1970's for each flyway is summarized in table 4.14. Wintering duck

Table 4.11 — *Average percentages of days of small game and upland game bird hunting for selected species in the contiguous States, by major land ownership and the land ownership with major potential for increased hunting, by section, mid-1970's*

Hunted species	Ownership				Ownership with major potential for increased hunting
	National Forest	Other Federal	State[1]	Private	
Northeastern States					
Rabbits, hares	10	5	20	65	Private
Squirrels	5	5	15	75	Private
Quail	[2]	[2]	35	60	State, private
Pheasant	5	5	10	80	Private
Forest grouse	10	5	15	70	Private
Doves	[2]	5	20	75	Private, State
Woodcock	5	5	20	70	Private
North Central States					
Rabbits, hares	5	5	20	70	Private
Squirrels	5	5	35	55	Private
Quail	[2]	[2]	10	85	Private
Pheasant	[2]	[2]	15	85	Private
Forest grouse	15	[2]	20	65	All
Woodcock	10	10	20	60	All
Southeastern States					
Rabbits, hares	10	10	20	60	Private
Squirrels	20	10	15	55	Private
Quail	15	10	15	60	Private
Pheasant	[2]	[2]	10	90	Private
Forest grouse	40	10	20	30	National Forest
Doves	10	10	15	65	Private
Woodcock	20	10	20	50	All
South Central States					
Rabbits, hares	10	10	10	70	Private
Squirrels	15	10	15	60	All
Quail	10	10	10	70	Private
Forest grouse	40	[2]	20	40	National Forest
Doves	10	10	10	70	Private
Woodcock	15	10	10	65	All
Great Plains					
Rabbit, hare	10	10	10	70	Private, other Federal
Squirrels	10	[2]	5	85	Private
Quail	[2]	[2]	[2]	95	All
Pheasant	[2]	[2]	10	90	Private
Prairie grouse	15	10	10	65	Private, other Federal
Doves	[2]	[2]	[2]	95	Private
Rocky Mountain States					
Rabbit, hare	30	30	10	30	All
Squirrels	30	5	15	50	National Forest
Quail	10	20	5	65	Private
Pheasant	[2]	5	10	85	Private
Forest grouse	75	15	[2]	10	National Forest
Prairie grouse	10	45	5	40	Other Federal
Doves	10	20	10	60	All
Pacific Coast					
Rabbit, hare	40	25	5	30	Private
Quail	10	20	10	60	All
Pheasant	[2]	[2]	5	95	Private
Forest grouse	50	5	20	25	National Forest
Prairie grouse	[2]	30	10	60	Limited to none
Doves	20	10	10	60	Limited to none

[1] Includes some local government lands.
[2] Less than 3 percent.
Source: Data derived from information supplied by individual states.

Table 4.12 — *Trends in harvests of principal big game species and proportion of big game hunters pursuing species in the United States in 1975*

Proportion of hunters	Species	Principal range	Index of harvest (mid-70's = 100)			mid-1970's
			mid-50's	mid-60's	mid-70's	
Percent						*Number*
	Deer, white-tailed	Everywhere except western mountains and prairies	35	80	100	1,740,000
95	Deer, mule	Forested mountains, western desert foothills to Cascade Mountains	210	200	100	285,900
	Deer, black-tailed	Forest from Cascade Mountains west; coastal Alaska (Sitka black-tailed)	225	270	100	51,800
13	Turkey	Southeastern and Southern deciduous forest (eastern); Texas and Oklahoma (Rio Grande); western mountains of Colorado, Arizona, and New Mexico (Merriam's)	35	60	100	167,200[5]
7	Elk	Drier portions of Rocky Mountains (Rocky Mountain elk) and Cascade and Coastal Mountains (Roosevelt elk)	65	85	100	98,800
5	Bear, grizzly and brown	Forests of Wyoming, Idaho, Montana, and Alaska (grizzly bear); coastal areas of Alaska forests (brown bear)	—	95	100	750[3]
	Bear, black	Isolated blocks of coniferous and deciduous forest land	110	140	100	16,300
2	Pronghorn antelope	Open grasslands from Texas to Canada	60	75	100	81,900
1	Moose	Riparian and wetland habitats producing hardwoods in Alaska, Idaho, Wyoming, Montana, Utah, Minnesota, and Maine	— 35	80 70	100 100	10,000[3] 2,100[4]
[1]	Bighorn sheep	High mountain ranges in Alaska (Dall sheep), Northern Rockies (Rocky Mountain sheep), and the Southwest (desert sheep)	— 50	130 100	100 100	1,000[3] 400[4]
[1]	Mountain goat	Above timberline in Southern Alaska, Washington, Idaho and Montana, and Colorado	— 60	80 165	100 100	800[3] 600[4]
[2]	Javelina	Southwestern desert shrub and adjacent habitats	70	65	100	9,800

[1]Less than 1 percent.
[2]Not reported.
[3]Harvest in Alaska.
[4]Harvest in contiguous United States.
[5]About three-quarters were eastern turkeys.

Sources: Harvest information derived from U.S. Department of the Interior, Fish and Wildlife Service. *Big game inventory.* Washington, D.C., (annual reports) 1950-1970, and from National Rifle Association of America, *NRA hunting annual.* Washington, D.C., (annual publications) 1970-1977. Information on hunters derived from U.S. Department of the Interior, Fish and Wildlife Service. *1975 national survey of hunting, fishing, and wildlife associated recreation.* (Including unpublished supporting statistical data.) Washington, D.C.

populations were distributed among flyways in roughly the same proportions. The most heavily hunted species are:

Species	*Average breeding population 1955-1976 (Millions)*	*Apparent population trend from mid-1950's to early 1970's*	*Trend since then*
Mallard	8.8	Down	Steady
Green-winged teal	7.2	Down	Up
Greater and lesser scaup	6.7	Up	Up
Pintail	6.2	Down	Up
American wigeon	3.1	Down	Down
Northern shoveler	1.9	Down	Steady
Gadwall	1.4	Up	Down
Redhead	.7	Up	Up
Canvasback	.6	Up	Steady

The harvest of geese has not exhibited the radical fluctuations that have characterized the duck harvest, primarily because breeding habitat conditions in the northern forested and Arctic tundra regions of Canada and Alaska are more stable. The harvest of geese has increased in the United States since the mid-1950's and, in the first half of the 1970's, averaged about 1,600,000 birds per year. Canada geese have been most important, followed by snow and white-fronted geese.

Populations of the only swan species hunted in the United States, the whistling swan, increased from 81,000 in 1967 to 157,000 in 1976. About 1,000 have been harvested each year since 1971. Trumpeter swans, which are found in western Montana, northeastern Idaho, Wyoming, Utah, Alaska, and Canada, are estimated to number about 6,000.

In every section of the country, more waterfowl are harvested on private lands than on any other ownership. Federal lands are most important in the interior West, but they contribute only a fourth of the total harvest in any section. State lands are most important in the Northeast and on the Pacific Coast.

Supply of Nongame Wildlife

For the great majority of wildlife species that are of particular interest to "nonconsuming" recreationists, there is little empirical evidence of changes in population levels. Trends have been evaluated systematically only for bird populations. Variations in the numbers of birds in North America have been derived from breeding population studies, autumn migration counts, and winter population counts.

Preliminary analyses indicate that most nongame bird species associated with forest habitats have had relatively stable populations during the past decade when viewed on a continent-wide basis, although there have been significant changes in the populations of particular species (table 4.15). Most of these changes appear to be related to changes in forest stocking levels. A number of eastern species have suffered significant population declines. Compensating increases in populations of species typical of stocked forest stands in the same areas is suggested by available data, but the evidence is not strong enough to permit firm conclusions.[22]

Raptorial birds, often regarded as the most sensitive indicators of environmental change, have been monitored by autumn migration counts, or "hawk watches," and by winter population counts, or "Christmas bird counts." Raptor population trends were examined for 12 species for the period 1967-74 to see whether changes could be correlated with decreases in the use of organochlorine pesticides and increased protection of the birds. The findings include statistically significant decreases in the red-shouldered hawk and increases in the sharp-shinned and Cooper's hawk. Lesser decreases (not statistically significant) were found in populations of the Harris hawk, northern harrier, and the peregrine falcon, and lesser increases were found in goshawk, kestrel, and great horned owl populations.[23]

In a separate effort, average population levels of 17 raptorial species in the period 1948-1966 were compared to average levels in 1967-74. Five species had greater populations in the more recent period, five had lower levels, and seven had no sigificant change.

[22] Capen, D. E., and S. P. Ahlefeld. Habitat associations and population trends of nongame birds in forest ecosystems. School of Natural Resources, Univ. Vermont, Burlington, Progress report (mimeo). 1979.

Cooper, R. J., and D. E. Capen. The 1979 RPA national assessment of wildlife and fish: nongame birds. School of Natural Resources, Univ. Vermont. Burlington. Final report (mimeo). 61 p. 1978.

Robbins, C. S., and A. J. Erskine. Population trends in nongame birds in North America. *In* Trans. No. Amer. Wildl. and Nat. Res. Conf. 40:288-293. 1975.

[23] U.S. Department of the Interior, Fish and Wildlife Service Environmental Assessment: proposed falconry regulations. Washington, D.C., 61 p. 1976.

Figure 4.5

Numbers of Big Game Animals in Populations Relative to Numbers of Hunters in the Contiguous United States by Section, Mid-1950's through Mid-1980's

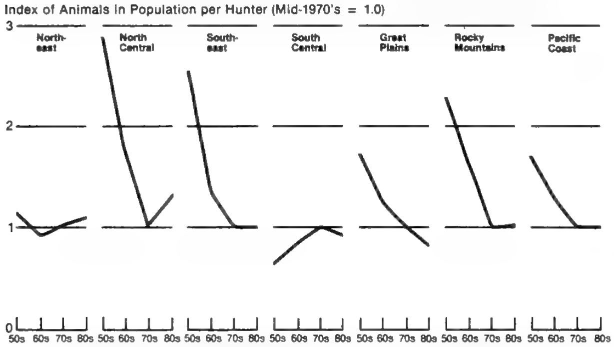
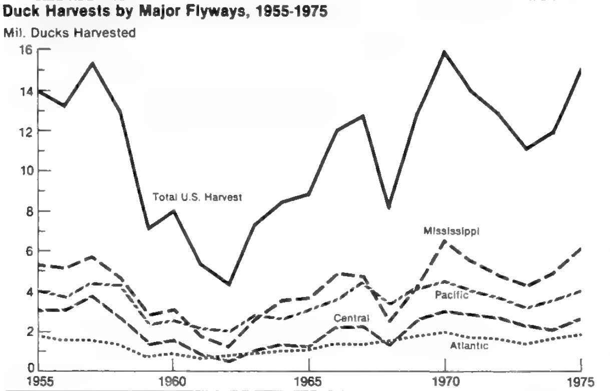


Figure 4.6

Duck Harvests by Major Flyways, 1955-1975



Supplies Related to Ecological Perceptions

Ecological demands are largely focused on insuring the preservation of individual species and of entire communities of species. The Endangered Species Act addressed the first concern. The Marine Mammal Protection Act addressed the second concern by emphasizing that the management of entire ecosystems, including communities of wild fauna rather than species-by-species management, offers the best chance to realize the full continuum of wildlife values.[24]

The only available direct measure of the degree to which ecological demands are being met is the success (or lack of success) in preventing the extinction of individual species.

It has been suggested that the historical rate of species extinction in the United States has paralleled the rate of population growth.[25] Fossil evidence indicates that in prehuman times mammal and bird species became extinct at the rate of three per century. The rate of extinction apparently had accelerated to about 150 species per century by the 1800's. Eighty-five species and subspecies of vertebrate animals are known to have been extinguished since 1900. There is general agreement that extinctions are likely to continue to accelerate in the absence of intense (and expensive) corrective actions.[26]

Because the present process of defining and listing species as endangered or threatened is quite new, the benchmark for measuring success in preventing extinction is not firm. Efforts are at an early state of development. For endangered species, most available resources are still being devoted to determining exactly where they are found, their habitat requirements, the potential extent of their range, and strategies for their rehabilitation. Since the first official Federal listing of endangered species was made, fewer than 10 species have been delisted because their numbers have increased to the point where they are no longer endangered.

Many endangered and threatened species are geographic isolates, the most obvious being those endemic to oceanic islands. Some species never were abundant but developed in severely restricted habitats. The "islands" of suitable habitats that support other rare species are remnants of vegetation types that were once much more extensive. A continual subdividing or shrinking of blocks of similar vegetation is one explanation for the decline of carnivorous birds and mammals.

The remaining endangered species have suffered from a variety of ills, including exposure to chemicals at concentrations greater than could be tolerated. In a number of instances, and particularly in the Pacific and Caribbean Islands, the introduction of competing exotic species and of predators has had devastating impacts on native fauna.

[24] This has been generalized to say that management activities should lead to maximizing the total complex of values of an ecosystem, that future management options should be preserved, and that the risk of long-term adverse effects should be minimized by explicitly making allowances to compensate for incomplete knowledge, for imperfect decisions, and for imperfect implementation of decisions. Holt, S. J., and L. M. Talbot. New principles for the conservation of wild living resources. Wildlife Monograph 59, Wildlife Society. 33 p. 1978.

[25] Opler, P. A. The parade of passing species: a survey of extinctions in the U.S. The Science Teacher 44(1):14. 1977.

[26] Fawcett, C. W. Vanishing wildlife and federal protective efforts. Ecology Law Quarterly 1(3):520-560. 1971.

Table 4.13 — *Average percentages of days of big game hunting for selected species in the contiguous States and Alaska, by major land ownership and the land ownership with major potential for increased hunting, by section, mid-1970's*

Hunted species	Ownership				Ownership with major potential
	National Forest	Other Federal	State[1]	Private	
Northeastern States					
Deer	5	5	20	70	Private
Turkey	25	[2]	15	60	Private
Bear	25	5	15	55	Limited to none
North Central States					
Deer	15	5	20	60	Private, State
Turkey	30	[2]	25	45	National Forest, State
Bear	45	5	25	25	National Forest
Southeastern States					
Deer	30	15	20	35	All
Turkey	30	15	25	30	All
Bear	60	[2]	[2]	40	Limited to none
South Central States					
Deer	20	15	15	50	All
Turkey	30	15	20	35	All
Bear	40	[2]	10	50	Limited to none
Great Plains					
Deer	5	5	[2]	90	Private
Turkey	25	5	10	60	Private
Antelope	10	[2]	5	85	All
Rocky Mountain States					
Deer	40	20	10	30	All
Turkey	40	15	10	35	National Forest
Bear	60	20	5	15	National Forest
Antelope	10	45	10	35	Other Federal
Elk	80	5	5	10	National Forest
Moose	70	10	5	15	National Forest
Pacific Coast States					
Deer	40	15	5	40	National Forest
Turkey	20	[2]	10	65	All
Bear	60	15	5	20	National Forest
Antelope	[2]	70	10	20	Other Federal, State
Elk	60	5	15	20	National Forest
Alaska					
Deer	90	10	[2]	[2]	National Forest
Bear	5	90	5	[2]	All (black bear only)
Moose	5	80	15	[2]	None
Caribou	[2]	90	10	[2]	None

[1] Includes local government lands.
[2] Less than 3 percent.
Source: Data derived from information supplied by individual States.

Table 4.14 — *Average distribution of duck harvest within flyways in the United States 1970-1977, by species*

(Percent)

Species	Flyway				
	Alaska	Pacific	Central	Mississippi	Atlantic
Mallard	28	30	38	39	21
Pintail	25	24	7	3	2
Wood duck	0	1	1	11	16
American widgeon	16	11	6	4	4
All teal	14	16	21	18	12
Black duck	0	0	[1]	2	15
Gadwall	1	3	9	5	1
Shoveler	5	6	3	2	1
Canvasback	[1]	1	[1]	[1]	1
All scaup	5	1	3	6	8
Ring-necked duck	[1]	1	1	5	7
Redhead	[1]	1	2	1	[1]
Goldeneye	2	[1]	[1]	[1]	1
Others	4	5	9	4	11
Total	100	100	100	100	100

[1]Less than 1 percent.

Source: U.S. Department of the Interior, Fish and Wildlife Service, unpublished file of Office of Migratory Bird Management, Washington, D.C. 1978.

Populations of most nongame bird species with forest habitats have been relatively stable in recent decades.

Table 4.15 — *Relative population trends of selected nongame birds on forest land, by species and section of the contiguous States, 1968-1977*[1]

Species	Contiguous States	Northeast	North Central	Southeast	South Central	Rocky Mountains Great Plains	Pacific Coast
Indigo bunting	+++	0	+++	+++	--	++	[2]
Horned lark	++	--	0	---	0	++	-
Red-eyed vireo	++	+++	0	++	0	0	--
Savannah sparrow	++	0	+++	0	[2]	0	0
Northern parula	+	0	0	0	0	[2]	[2]
Tufted titmouse	0	+++	--	0	0	0	[2]
Pine warbler	0	++	+++	0	0	[2]	[2]
Warbling vireo	0	0	0	0	0	++	0
Pileated woodpecker	0	0	0	0	++	[2]	-
Black and white warbler	0	0	0	0	0	[2]	[2]
Eastern wood pewee	0	0	0	++	--	0	[2]
Eastern kingbird	0	0	+	-	-	0	-
Loggerhead shrike	0	[2]	--	0	0	-	0
Eastern meadowlark	-	---	---	--	+	0	[2]
Chipping sparrow	-	--	+++	---	---	0	++
Grasshopper sparrow	--	--	0	---	0	-	[2]
Dickcissel	---	[2]	---	---	--	--	[2]
Vesper sparrow	---	--	--	[2]	[2]	0	0
Brown thrasher	---	--	0	0	---	0	[2]

[1]Entry of zero means no significant trend. Entry of plus sign (minus sign) means significant increase (decrease) in population. Increase in number of signs indicates stronger evidence. See source for statistical meaning.

[2]No data, or species is not resident in section.

Source: D. E. Capen and S. P. Ahlefeld. Habitat associations and population trends of nongame birds in forest ecosystems. School of Natural Resources. University of Vermont. Burlington. Study progress report (mimeo.) 1979.

Implications of Not Meeting Demands for Wildlife and Fish Resources

It seems clear that demands for wildlife and fish resources are likely to increase in the decades ahead. While the ability to predict future supplies of these resources is limited, continuing losses and degradation of habitats suggest that even maintaining some present population levels will be difficult. To the extent that demands for wildlife and fish are not met, there will be a reduction in some of the values that might have been realized from these resources. The major kinds of direct and derived values associated with these resources are summarized in table 4.16.

Pacific salmon currently are the basis for the employment of both commercial fishermen and employees in shore-based fish processing plants. Any reduction in current harvests would lead to losses in these jobs and to locally severe economic consequences in fishing communities in Alaska and the Northwest. Steadily increasing market prices for salmon products suggest that increases in salmon populations would result in income and employment above current levels.

Trapping most commonly provides supplemental income to rural residents. A reduction in the opportunity to harvest furbearers would result in losses of some income to many individuals across the Nation.

Unless action is taken to increase supplies, there will be intensifying competition and less satisfying opportunities for outdoor recreation based on wildlife and fish resources.

Table 4.16 — *Major values associated with wildlife and fish occurring on forest and range land*

Category of values	Major components	Direct values	Derived values
Market products	Marketed salmon products	Income, employment of fishermen	Income, employment in dependent fish processing and marketing industry
	Marketed fur products	Income of trappers	Income, employment in dependent fur processing and marketing industry
			Contributions to national balance of payments
	Nonmarketed wildlife and fish consumed as food	Dollar-equivalent income supplements of subsistence users (major) and of sport hunters and anglers (less)	
Social experiences	Recreational experiences	Contributions to physical and mental health	Income, employment in dependent recreation industry
			Funds to support State wildlife and fish management programs
	Cultural experiences	Preservation of dependent cultures and means of self-identification	
Ecological perceptions	Perceptions that species and communities of species should be preserved	Preservation of national heritage, gene pools, opportunities for study and understanding	Natural control of economic pests
			Benchmark for measuring conditions where resources are not preserved

Current projections suggest that substantial increases in opportunities to hunt and fish will be necessary to meet future recreational demands. To the extent additional opportunities are not available, conditions will be more crowded and success ratios will be lower. In addition, some who would have participated will not have that opportunity. This is already true for hunters of some big game species which are available in such limited numbers that only the winners of special lotteries can hunt them.

The current numbers of hunters and sport anglers and their expenditures indicate that such recreation is valuable to the participants. Evidence that recreationists are willing to spend more for some kinds of activities than others provides a basis for a rough ranking of the values of these activities to the recreationists. For example, differences in average expenditures per day (table 4.3) suggest that the loss of a given number of recreation-days of salmon fishing or big game hunting would represent a larger loss to participants than would a loss of the same number of opportunities for warmwater fishing or small game hunting. This seems reasonable because (1) that loss would represent a larger share of all opportunities of the more highly valued activities, and (2) there are generally perceived to be fewer opportunities to substitute other "equivalent" experiences for those that are most highly valued.[27]

A second-order consequence of not meeting demands for recreational opportunities would be a slowing in the growth of income to the supporting recreation industries (although other firms might benefit as substitute activities become more popular). Many rural communities depend substantially on the expenditures of hunters and anglers, and the manufacture of sport hunting and fishing equipment is of national economic significance. The 1975 national survey of the Fish and Wildlife Service estimated that sport hunters and anglers spent more than $15 billion annually in the United States.[28]

Because most money available to State agencies concerned with fish and wildlife is derived from sportsmen, a reduction in hunting and fishing participation could reduce or slow the growth in State funds available for fish and wildlife activities.[29] For figure 4.7, the source of the $135 million available to the States for the administration of inland sport fisheries and wildlife resources in 1971 are shown in figure 4.7.

Wildlife- and fish-related activities have social and cultural implications, whether those activities are primarily economic or recreational in nature. Wild animals provide an opportunity for commercial fishermen and trappers to maintain a particular way of life and contribute to the lifestyles of recreationists. Where these resources are important for ceremonial or religious purposes, they may be critical to the continuing existence of a particular culture.[30]

The extinction of a species diminishes the Nation's natural heritage and reduces future options for study and, perhaps, breeding. Losing a particular component of fauna from an ecosystem can lead to economic losses, as when reductions in the populations of birds that eat insects lead to buildups of insect populations; these insects then must sometimes be controlled by chemicals or the introduction of predators. And a reduction in the variety of wildlife in a particular area probably diminishes the satisfaction of many recreationists.

A somewhat similar cost is incurred when animal populations are out of balance with the way man chooses to use lands. Animals cause economic losses by destroying agricultural crops and livestock, delaying successful regeneration, and reducing growth rates on forest lands. It is believed that the value of agricultural crops lost to wildlife exceeds $100 million per year. Rodents probably cause the most damage, but birds and mammals also are locally important causes of damage to particular crops. Losses of livestock to predators were reported at about $170 million in the 22 Western States in 1973, including $80 million for cattle and calves, $53 million for sheep and lambs, $32 million for chickens and turkeys, and $5 million for pigs and hogs. Coyotes, bears, foxes, lions, raccoons, and skunks all contributed to these losses.[31]

Problems in Improving the Status of Wildlife and Fish

The preceding has compared trends in demands and supplies and broadly discussed the implications of any future imbalances. This section provides an overview of the factors that inhibit correcting imbalances, primarily from the perspective of the forest and range land manager.

The major problems facing managers have been ranked by importance for each part of the Nation by Forest Service wildlife and fisheries biologists, who are charged with very broad land and water management responsibilities for the National Forest System. These problems, listed in order of overall national importance, are presented in table 4.17.

Greatest concern was shown for the broad category of conversions of forest and range vegetative types by man. Such conversions alter faunal communities radically. More specifically, the continuing loss and degradation of wetlands and riparian zones and of old-growth components of forests pose significant problems in discharging Federal land management

[27] There is evidence, for example, that waterfowl hunters have been turning to woodcock in the Northeast. Artman, J. W. The status of American woodcock 1975. U.S. Department of the Interior, Fish and Wildlife Service. Washington, D.C. 1975.

For more general discussions concerning substitutability among outdoor recreation activities, see:

Hendee, J. C., and R. J. Burdge. The substitutability concept: implications for recreation research and management. J. Leisure Research. 6:157-162. 1974.

Krieger, M. H. What's wrong with plastic trees? Science 179:446-455. 1973.

For discussions concerning the determinants of satisfaction in hunting and fishing, see:

Potter, D. R., J. C. Hendee, and R. N. Clark. Hunting satisfaction: game, guns, or nature? *In* Trans. No. Amer. Wildl. and Nat. Res. Conf. 38:220-229. 1973.

Stankey, G. H., R. C. Lucas, and R. H. Ream. Relationships between hunting success and satisfaction. *In* Trans. No. Amer. Wildl. and Nat. Res. Conf. 38:235-242. 1973.

For a discussion of the contribution of general outdoor recreation activities to physical and mental health, see the earlier chapter on outdoor recreation.

[28] The prices recreationists will pay to use private lands for wildlife or fish-centered recreational activities sometimes have been found to be greater than the values of those lands in commodity production. For example, an Arizona study found that twice as many dollars could be charged for sport hunting on certain Arizona rangelands as for cattle ranching. Martin, W. E., and R. L. Gunn. Economic value of hunting, fishing, and general rural outdoor recreation. Wild. Soc. Bul. 6(1):3-7. 1978.

[29] Wildlife Management Institute. National survey of state fish and wildlife funding. Washington, D.C., 40 p. 1973.

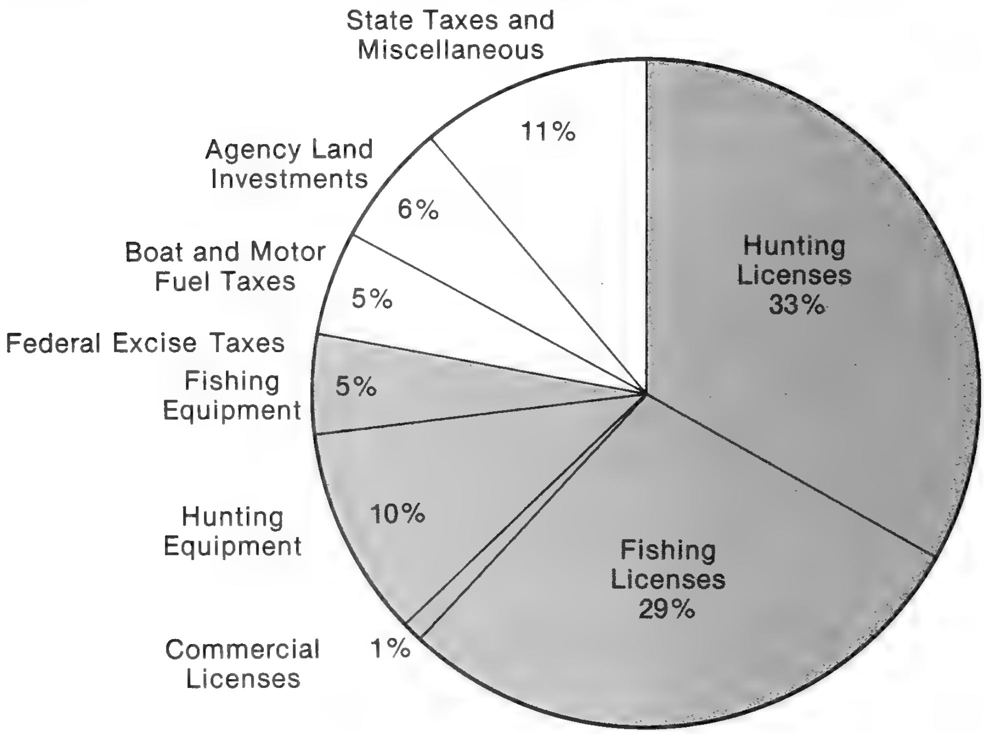
[30] For a comprehensive discussion of the cultural significance of salmon in the Northwest, see Department of Agriculture and Resource Economics, Oregon State University. Socio-economics of the Idaho, Washington, Oregon, and California coho and chinook salmon industry. Report to the Pacific Fishery, Management Council. Corvallis, Oreg. Vols. A and B. 1978.

[31] U.S. Department of the Interior, Fish and Wildlife Service National Animal Damage Control Program: environmental statement (preliminary draft). Washington, D.C. 1978.

U.S. Department of Agriculture, Economic Research Service. Sheep and lamb losses to predators and other causes in the western United States. Agriculture Economic Report 369. Washington, D.C. 41 p. 1977.

Figure 4.7

Sources of Funds for Fish and Wildlife Management—1971



responsibilities. Second-rank concerns of these biologists include the impacts on terrestrial and aquatic habitats of urban and energy developments, decreasing water quality (in spite of recent legislation), and difficulties in maintaining the variety of habitat conditions necessary to support a wide variety of animal species.

When considering particular species in particular geographic areas, other problems are seen as most critical. Illegal harvesting of black bears, mink, panthers, turtles, and white-tailed deer in the South, over-harvesting of salmon in the Pacific Northwest, competition by exotics in Hawaii, and withdrawals of water in the Rockies and on the West Coast are all regionally significant problems for some wildlife and fish species.

Modifications of Terrestrial Ecosystems

The major broad problem in maintaining or enhancing socially desirable animal populations and communities of animals has been the conversion of forest and range lands to lands used for agricultural and urban-related activities. The extremes are found in Alaska, which is relatively untouched by development, and in the Pacific and Caribbean Islands, where the native ecosystems have been eradicated or at least greatly modified. These changes have been accompanied by changes in species occurrence and population levels.

In general, current conditions in the eastern United States are more favorable for deer and farm-type wildlife than were the mature forests in the time of the first colonists. On the other hand, the available habitat has been decreased for those large mammals that require extensive blocks of vegetation, such as elk, and for large birds of prey and cavity-nesting birds that require (commercially) overmature trees. At the extreme, particular populations have become geographic isolations that are unable to interbreed with other populations. This is a major concern in the management of a number of large mammals, including the mountain lion, bighorn sheep, and wolf.

By the early 1900's, most species requiring extensive habitats, such as wolf and elk, were gone from the eastern United States and there had been sharp

Table 4.17 — *Relative importance of problems faced by managers of wildlife and fish associated with forest and range lands in the United States, by region, as judged by Forest Service wildlife and fisheries biologists*[1]

Type of problem	Northeast, North Central	Southeast, South Central	Rocky Mountains — Great Plains				Pacific Coast		Alaska	Hawaii, Puerto Rico
			Northern	East Central	West Central	Southern	Northern	Southern		
Conversion of vegetative types by man	1	1	2	1	1	1	1	1	2	1
Loss of wetlands and riparian zones	1	2	1	1	1	1	1	1	2	1
Loss of specialized habitats especially old growth, snags	1	1	1	2	1	1	1	1	2	1
Broad disturbances from urban development	1	2	2	1	1	1	2	1	2	2
Broad disturbances from energy development	1,3[2]	1,3[2]	2	1	1	1	1	1	1	3
Restrictions on management in special-use areas	2	1	1	1	1	1	2	3	1	3
Lack of habitat diversity	2	3	1	2	1	2	1	1	2	2
Deteriorating water quality	1,2[3]	2	2	2	2	1	1	2	1	3
Inadequate water quantity or inadequate distribution	1,3[4]	3	2	2	1	1	1	1	3	3
Fragmentation of habitats	2	3	2	2	2	2	2	1	3	1
Loss of habitats through natural plant succession	1,2[5]	1	2	2	1	3	3	2	2	3
Industrial and mining pollution	1	2	3	1	2	2	3	2	2	3
Inadequate harvest regulation	3	1	3	3	3	3	2	3	1	1
Competition of nonnative species	3	1,3[6]	3	3	2	2	3	2	3	1
Poor health of animal population (parasites, diseases)	3	3	2	3	3	2	3	3	3	2

[1] "1" means judged most important.
[2] 1 — Appalachia; 3 — elsewhere.
[3] 2 — Lake States; 1 — elsewhere.
[4] 1 — Interior North Central; 3 — elsewhere.
[5] 1 — Lake States; 2 — Interior North Central.
[6] 1 — Texas; 3 — elsewhere.

declines in populations of grizzly bears, antelope, and mountain sheep in the West. But there also had been substantial increases in populations of wildlife associated with farming, such as mourning doves, bobwhite quail, cottontail rabbits, meadowlarks, and crows. The regrowth of previously cutover forest lands was accompanied by tremendous increases during the thirties in the numbers of white-tailed deer in the East and, a decade later, in black-tailed deer in the West. Prairie grouse in the Lake States gave way to ruffed grouse; beaver, coyotes, and black bears became abundant.[32]

Man's activities tend to lead to "islands" of homogeneous vegetation. For example, on lands devoted to commercial timber production, every effort is made to speed the juvenile stage of growth so timber can be harvested as early as possible. On range lands, shrubs and forbs are removed and grasses encouraged to provide as much forage as possible for livestock. As a result of such activities, the range of habitats available to wildlife within an area is reduced and the species remaining are the relatively few adapted to this limited range (although the number of animals within each species may increase). The borders between homogeneous areas must provide the "edge" that is essential for a wide variety of species.

Natural succession also changes habitat conditions, generally in the opposite direction of man's activities. Abandoned agricultural lands tend to return to forests. Openings in forests are filled in as new trees grow. On prairie agricultural lands, annual plants are replaced by combinations of perennial grasses, herbs, and shrubs. To the extent that those interested in wild animals favor the species associated with farm lands or that require openings in forests, the manager has the task of fighting nature to artificially maintain approximately those conditions.

Loss of Wetlands

During the two centuries of the Nation's existence, the area of wetlands in the contiguous States has been reduced by nearly half, from 127 million to about 70 million acres. These areas provide key habitat for waterfowl and many other wildlife species. The areas currently most threatened by drainage, primarily for agricultural purposes, and the most critical areas of waterfowl habitat, are shown in fig. 4.8. Drainage of wetlands in the prairie-pothole country of Minnesota and the Dakotas and in the coastal zone of the southeastern United States poses a continuing threat to wetland-associated wildlife populations.

The "edge" where two different vegetation types meet is an essential habitat for many species of wildlife.

Overall, perhaps 80 percent of all riparian habitats found in wetlands adjacent to rivers, streams, and other bodies of water has been lost. No ecosystems are more essential to the survival of the Nation's fish and wildlife. For example, western riparian ecosystems contain approximately 42 percent of the mammal species of North America, 38 percent of the bird species, 30 percent of the reptiles, and 14 percent of the amphibians. Seventy-seven percent of the breeding bird species and 75 species of fish of the Southwest depend on riparian ecosystems. Eastern wildlife most severely affected by the loss of riparian wetlands includes otter, muskrat, mink, beaver, raccoon, Canadian geese, and wood ducks.[33]

Endangered species are associated with at least 20 percent of all riparian lands. Nine riparian wetland habitats are on the Critical Habitat List and 17 more have been proposed. (A critical habitat is defined by the Endangered Species Act as the area of land, air, or water required for the normal needs and survival of a species listed as endangered or threatened.) Sixty-four species which are dependent upon riparian ecosystems have been listed as endangered and 47 more have been proposed for listing.

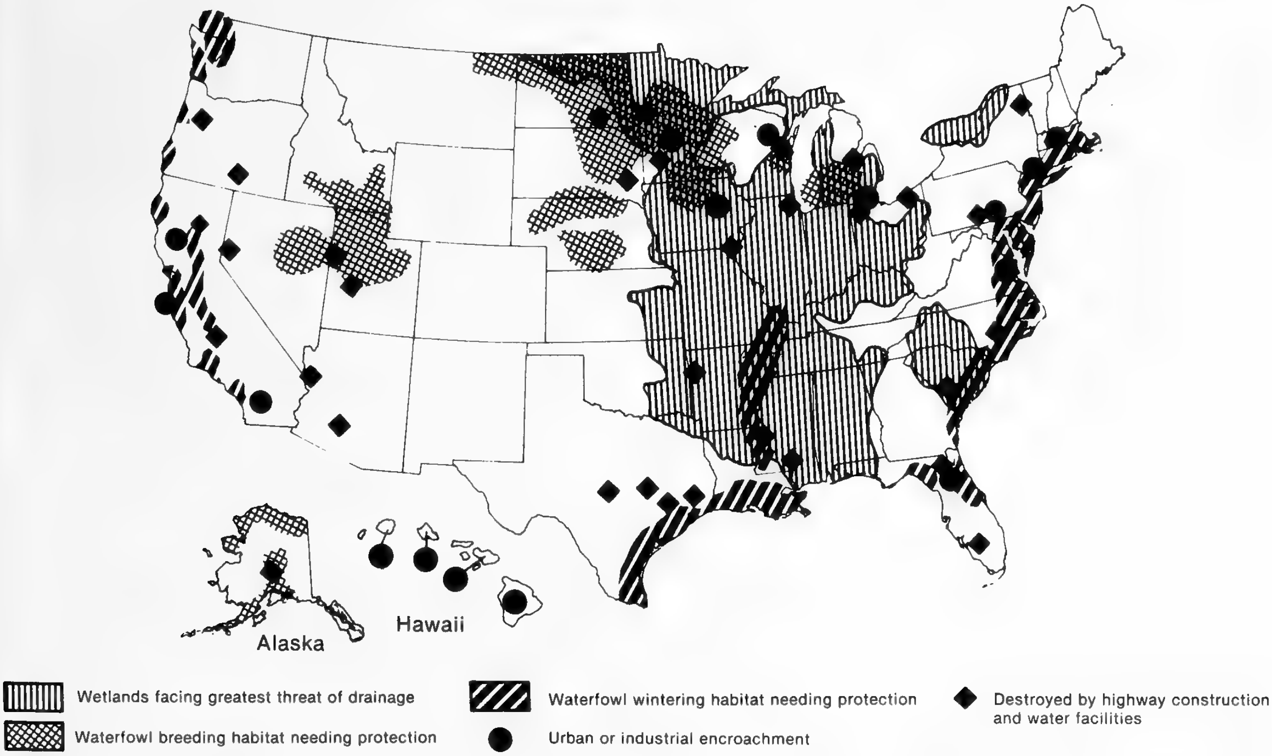
When wetlands are filled or drained, they are usually turned to other valuable but competing uses. Indeed, one-quarter of all privately-owned agricultural soils in the United States were originally wetland. The recent high price of soybeans has stimulated the clearing and draining of bottom land hardwoods in the Lower Mississippi Valley and the southeastern coastal States. Similar activities in the prairie

[32] Abstracted from Allen, D. L. Historical perspective. *In* Land use and wildlife resources. National Academy of Sciences. Washington, D.C. 128 p. 1970.

[33] Council on Environmental Quality. Environmental quality—1978. Washington, D.C. p. 316. 1978.

Figure 4.8

Status of Wetlands in the United States



States resulted when the price of wheat accelerated after large sales to the Communist bloc nations in the early 1970's.

Riparian habitats on rangelands are very susceptible to damage from overgrazing by livestock. Removal of tree cover in the understory is of special concern, particularly in the Southwest where this relatively limited habitat is vital to the native fauna. Its removal reduces wildlife population levels and ultimately the variety of wildlife that can be supported. When riparian lands are grazed too heavily, streambanks are damaged, movement of sediment into the stream channel is accelerated, stream channels tend to become wider and shallower, and the water becomes warmer. These physical changes may adversely affect aquatic organisms. To some degree, downstream habitats are also affected.

Modifications of Aquatic Ecosystems

The relative importance of current water-related activities and conditions that have major implications for wildlife and fish is shown by section in table 4.18. The problems of major concern include reductions in streamflows, physical changes to free-flowing streams and rivers, pollution, and sedimentation.[34]

The consumptive use of water for urban, agricultural, and industrial purposes and the consequent reductions in streamflows is great enough in some areas to threaten the existence of aquatic organisms. This is particularly true in the Southwest and in the southern portions of the Rocky Mountains and Great Plains. In especially dry years, problems also commonly occur in central California, as far north in the Great Plains as Kansas, and in the south central portion of Oregon and in southern Florida.[35]

[34] This discussion is primarily drawn from U.S. Water Resource Council. The Nation's water resources — Part III, functional water uses, Chapter 10: water requirements for fish and wildlife and related instream flows (review draft). p. 232-270. 1978.

[35] An inference from the Supreme Court decision in the Rio Mimbres case of 1978 is that the Forest Service has no legal right to divert water solely for wildlife or fishery purposes in the western States; the applicability to other Federal land-managing agencies has not yet been tested. See Wengert, N. Reserved rights and Federal claims to waters. In Proc., Legal, institutional, and social aspects of irrigation and drainage and water resources planning and management. Amer. Soc. Civil Engineers. (NYC). p. 93-107. 1979.

Table 4.18 — *Relative importance to wildlife and fish of water-related activities and conditions in the contiguous States and Hawaii, by region, 1975*[1]

Source of concern	Northeast	North Central	Southeast	South Central	Rocky Mountains-Great Plains	Pacific Coast	Hawaii
Pollution, sedimentation, and eutrophication	1	1	2	3	1	2	—
Residential, commercial, industrial development	2	1	2	1	3	4	1
Dams, irrigation, navigation and channelization projects	3	2	1	3	1	3	3
Volumes and fluctuations of streamflows	4	—	3	4	2	1	—
Agriculture activities	3	3	—	2	4	—	2
Mining activities	4	4	3	—	3	—	—

[1]"1" means of greatest importance. No entry means not of major concern.
Source: U.S. Department of the Interior, Bureau of Outdoor Recreation. *Nationwide analysis of outdoor recreation.* 1975. *In* U.S. Water Resource Council. *The Nation's water resources — Part III, Chapter 8; Water requirements for recreation and related resource considerations* (review draft). p. 203, 1978.

Free-flowing streams and rivers have been physically changed for many purposes, including power generation, flood control, and transportation routes for barges. While most hydroelectric construction has been centered in the West, channelization continues as a major activity in the East, and particularly along the Mississippi River and its tributaries.

The damming of rivers, reductions in the flow of freshwater, and dredging of navigation waterways in coastal zones change water circulation patterns and the volumes of sediment entering estuaries. The sediments themselves are important, for they are sites for microbial activity responsible for the decomposition of organic matter. Substantial reductions in sediment loads lead to the erosion of tidal shores, beaches, and the deltas themselves.

Leveeing of the Mississippi River has altered the distribution of silt-laden freshwater to such an extent that the Louisiana coastline is subsiding rapidly. Saltwater intrusions are dramatically altering the freshwater and brackish marshes. On the Texas Gulf Coast, predicted increases in freshwater consumption may well lead to increased salinity, which would have a serious impact on the shrimp and shellfish industries and on fishery habitats. The diversion of freshwater supplies through the cross-Florida navigation system to Lake Okeechobee has reduced the extent of the Everglades and of the estuarine ecosystem off south Florida, and has increased the adverse impacts of normal dry years. Finally, massive diversions of water from the Sacramento and San Joaquin Rivers to supply southern California cities with water threaten to change San Francisco Bay from an estuarine to a marine environment; the anadromous fish and waterfowl populations of central California also have been affected.

Pollution and Sedimentation

Pollutants from a variety of sources, including agricultural and industrial chemicals, pose a threat to populations of wildlife and fish. Perhaps best known has been the sometimes devastating impact on large birds of prey, which accumulate some of the chemicals assimilated by organisms that are at lower levels in their food chains. The brown pelican, bald eagle, and peregrine falcon are species that have suffered from contamination of their food chains.

Pollution can have devastating effects on scenic beauty and on wildlife and fish habitat.

The Federal Water Pollution Control Act and its amendments established an interim national goal of ensuring waters of a quality sufficient to support water-related recreation, fish, and wildlife. The initial concentration of control efforts on point source pollution was successful to the point that non-point source pollution (primarily in the form of chemicals and sediment carried by surface runoff from agricultural lands, urban developments, and sites disturbed by logging operations and road construction) is now the major concern.

In 1940, surface mining accounted for less than 10 percent of domestic coal production. Currently, about half of our coal is produced in this manner, with disturbances distributed over 4 to 5 million acres. Strip mining is now expected to increase substantially in the East and in the northern Great Plains and Rocky Mountains with attending increases in erosion and sediment loads downstream. The ecology of streams might be changed through changes in runoff patterns, changes in sediment loads, changes in temperature regimes, or by chemical enrichment or toxic pollution.

The effects of sediments on aquatic organisms include direct fish kills, covering of spawning beds of trout and salmon, reductions in populations of a variety of aquatic organisms, reduction in light transmittance, and alteration of streamflow patterns. Desirable species can be seriously reduced in number. At the same time, conditions may become favorable for less desired species.

The presence of toxic waste materials in runoff waters can affect organisms by eliminating certain species if concentrations are great. Lesser concentrations can suppress stream productivity and the growth rate or reproduction of many aquatic species. The duration of toxic water pollution can be long term. In Appalachia, it is estimated that the time required to completely leach out toxic materials from spoil piles can be as long as 3,000 years.

Other Problems in Management

In addition to habitat conditions, there are other kinds of problems facing wildlife and fish managers.

Harvest regulation. — For most species, regulations on harvesting are set by individual States. The intent is to adjust these regulations as required to insure continuing healthy populations while they are used for man's benefit.

Illegal taking of game species is a continuing problem to some degree across the Nation. In a few places, poaching of deer and other big game occasionally disrupts management programs for particular species.

Regulating the harvest of animals that migrate over considerable distances, particularly those that are international resources, is always a technically and politically difficult task. The harvests of both salmon and waterfowl are regulated under international agreements. That such agreements are difficult was illustrated by the "fish war" off the northeastern coast between Canada and the United States in the summer of 1978.

The ownership of harvest rights by Native Americans is a major issue in the Northwest and Alaska. Future court decisions will have a major influence on salmon fishing rights, rights to subsistence harvesting, and perhaps on the management obligations of agencies that are responsible for the habitats of salmon and other animals.

Competition of nonnative species. — Domestic cattle and sheep have had major impacts on wildlife and fish. In some areas, wild horses and burros now pose a significant problem in maintaining critical habitat for many species and frequently have the same kinds of impacts on riparian zones as those resulting from overgrazing by cattle. Introduced birds occasionally compete directly with native birds. In the Caribbean and Pacific Islands, nonnative animals have had devastating impacts on native fauna and flora.

Health of wild populations. — Although knowledge about the health of wild populations is still rudimentary, it is known that diseases and parasites are locally severe in many species. Hatchery-raised fish are particularly susceptible, as are some native populations of sockeye salmon. In the past, some parasites have been transferred from domestic sheep to bighorn sheep. Fowl cholera enteritis and botulism have also had severe impacts on waterfowl populations. It is likely that diseases are more important in limiting populations than is now generally recognized.

Problems Perceived by States

State agencies responsible for wildlife and fish management have defined a number of problems that are barriers to improving the condition of those resources.[36]

Western States particularly feel that shortages of dollars and skilled biologists are major barriers.

Absolute shortages of suitable habitat and frequent poor quality habitat are major problem areas. The management of private lands in the East and on the West Coast and inadequate cooperation of Federal land-managing agencies with State fish and wildlife agencies in the West are frequently cited problems.

[36] Schweitzer, Cushwa and Hoekstra. 1978. *op. cit.*

Agricultural, grazing, timber, and water management practices are all seen as critical for particular species.

Shortages of animals for transplanting, limited capabilities of fish hatcheries, overharvesting in the East, and pesticides and pollution are other problem areas. Lack of knowledge of the life cycle requirements of wildlife and fish, lack of adequate guidelines for their management, and the need for public understanding and acceptance of management activities have also been noted.

Problems Perceived by Recreationists

Those who hunt and fish for sport generally share the managers' concern for ensuring suitable habitats. Hunters, regardless of the type of hunting, rank the most serious problems in the following order:[37]

- posting of private lands against hunting and closure of access to public lands
- loss of game habitat
- littering and trespassing
- illegal hunting

In addition, big game hunters say they do not hunt more because of a lack of animals, a too-high cost of hunting, concern for their personal safety, and regulations that they find too restrictive.

Most anglers agree that they would like to see improved fish habitat conditions, increased stocking programs, better access to fishing sites, and stricter enforcement of fishing regulations. Warmwater anglers are particularly concerned about water pollution, competition from speedboats and water skiers, and too many other anglers. Those who prefer coldwater fishing call for longer seasons, more "wild" trout streams, and streams where only fly fishing is permitted. Salmon anglers frequently feel that a major need is to restrict commercial fishing.

Opportunities to Maintain and Enhance Wildlife and Fish Resources

It is clear that the use of each of our forest and range ecosystems will continue to increase. The preceding discussion has suggested that the values inherent in our wildlife and fish resources will generate more intense pressures on many animal populations. At the same time, some of the habitats which are critical to these resources will be lost or degraded if present trends in the treatment of forest and range lands continue.

Many of the uses and modifications of our land and water base that have major undesirable implications for wildlife and fish resources result from strong social and economic forces. The resulting problems cannot be resolved just by the wildlife profession, by public resource or land managing agencies, or by the owners of private lands. Their resolution depends upon a general recognition of the values of wildlife and fish and a willingness to make the tradeoffs necessary to capture those values.

This is particularly true with regard to activities that radically alter aquatic systems, such as the discharge of pollutants, the construction of dams, channelization, and water diversion projects. Comparable problems in terrestrial systems include the spread of agricultural activities to forest and range lands, and particularly to wetlands, and the encroachment of residential and industrial developments, especially those at the edges of waters and on big game winter ranges. Energy developments already pose major problems to wild fauna in some areas and will become more significant, particularly along the ocean coasts and in the interior West.

The general evolution of wildlife-oriented laws reflects the realization that Federal legislation is sometimes essential to deal with these problems. A supportive body of State laws has also been developed to deal with more localized problems.

Because forest and range ecosystems will continue to be used for a variety of purposes, specific wildlife populations will continue to be depleted for relatively short periods of time. In general, though, there are a variety of opportunities for ensuring continued substantial populations of most species; in the past, taking advantage of such opportunities has contributed greatly to the present abundance of the resources. The major, partially overlapping opportunities, can be categorized as managing habitats and populations, regulating or enhancing the use of animals, improving Federal-State-private cooperative programs aimed at enhancing the resources on private lands, and improving the research information base for management and decisionmaking.

Managing Terrestrial Habitats and Populations

The most direct approach to ensure that habitats of particular animals are protected is to eliminate or strongly control all activities that are not consistent with that goal. This has frequently been done to protect habitats for endangered and threatened species.

The National Wildlife Refuge System is probably the best-known example of forbidding destructive activities. In 1974, the system included about 40 million acres. The refuges are widely distributed, with

[37] 1975 National Survey of Hunting, Fishing, and Wildlife Associated Recreation, *op. cit.*

The most direct approach to protecting wildlife is the establishment of refuges. The National Wildlife Refuge System now includes about 34 million acres in the contiguous States.

half in Alaska and major concentrations in the pothole region of North Dakota and along the Atlantic Coast. Although the refuges were established primarily to ensure adequate habitat for international waterfowl populations, they also are critical for many other birds and mammals that occupy the refuges and the surrounding lands.

In general, the approach of relying on absolute prohibitions is expensive in that some of the significant values that could be realized from forest and range lands are foregone. The endangered red-cockaded woodpecker of the South provides an illustration.

This bird requires large trees for nesting and a mixture of age classes of mixed pines and hardwoods for foraging within a short distance of its nest. These requirements can be met in a forest managed for timber products, but only at an economic cost. Harvest rotations of 80 years in loblolly pine and 100 years in longleaf pine may be necessary. Under a management regime more concerned with the dollars or jobs associated with commercial timber products, at least two salable crops of trees could be raised in the same time periods. Similarly, an economic criterion would most likely discriminate against the hardwood component of the forest and lead toward a monoculture of pine.

The general situation facing the manager charged with multiple-use management or with coordinating wildlife management with the management of commodity products has been summarized in the context of timber management on private lands:[38]

> "The management procedures that enhance wildlife habitats are nearly all of a sort that cut profits to the timber operator: leaving strips or corners of mature trees uncut, leaving snags and potential snags in the forest, keeping clearcut blocks small, desisting from excessive use of herbicides and pesticides, maintaining some uneven-aged stands when even-aged stands are simpler to manage mechanically."

On private lands, the loss of profit to the landowner is easily understood. On public lands, there is a less apparent but still real cost because securing wildlife-related values for society frequently requires foregoing dollar returns and other resource values that would be realized if emphasis were placed on the wildlife.

There is a continuous scale of possible trade-off costs associated with the management of wildlife or fish. On the small-cost end are those activities that have little impact on the production or use of other resources. Removing logs from streams to allow free passage for salmon, installing nest boxes for waterfowl, and transplanting bighorn sheep are examples. At the large-cost end of the scale are activities that severely reduce the values derived from other resources. These activities would include fencing livestock away from streambanks or removing them entirely, reserving buffer strips of old-growth timber along streambanks for cavity-nesting birds and to minimize stream siltation, and closing forest roads to recreationists to minimize disturbances of wildlife.

In all but the unusual situations where extraordinarily high values (such as those associated with an endangered species) are at stake, the preferred management position is somewhere between these extremes. Historically, most activities modifying wildlife habitats on forest and range lands have been carried out in conjunction with grazing, logging, or road construction. In some instances, careful planning can insure that wildlife and other resources can be simultaneously enhanced without additional cost. In other instances, there is a modest cost, as when logging costs are increased because the required spacing of clearings and residual timber stands requires a somewhat longer haul or slower pace.

[38] Leopold, A. S. Wildlife and forest practice. *In* Wildlife and America. H. P. Brokaw (ed.) Council on Environmental Quality. Washington, D.C. p. 108-120. 1978. See separate chapters in the same book by Burger, G. V. and by F. H. Wagner for comparable discussions concerning conflicts between wildlife and agriculture and between wildlife and livestock management, respectively.

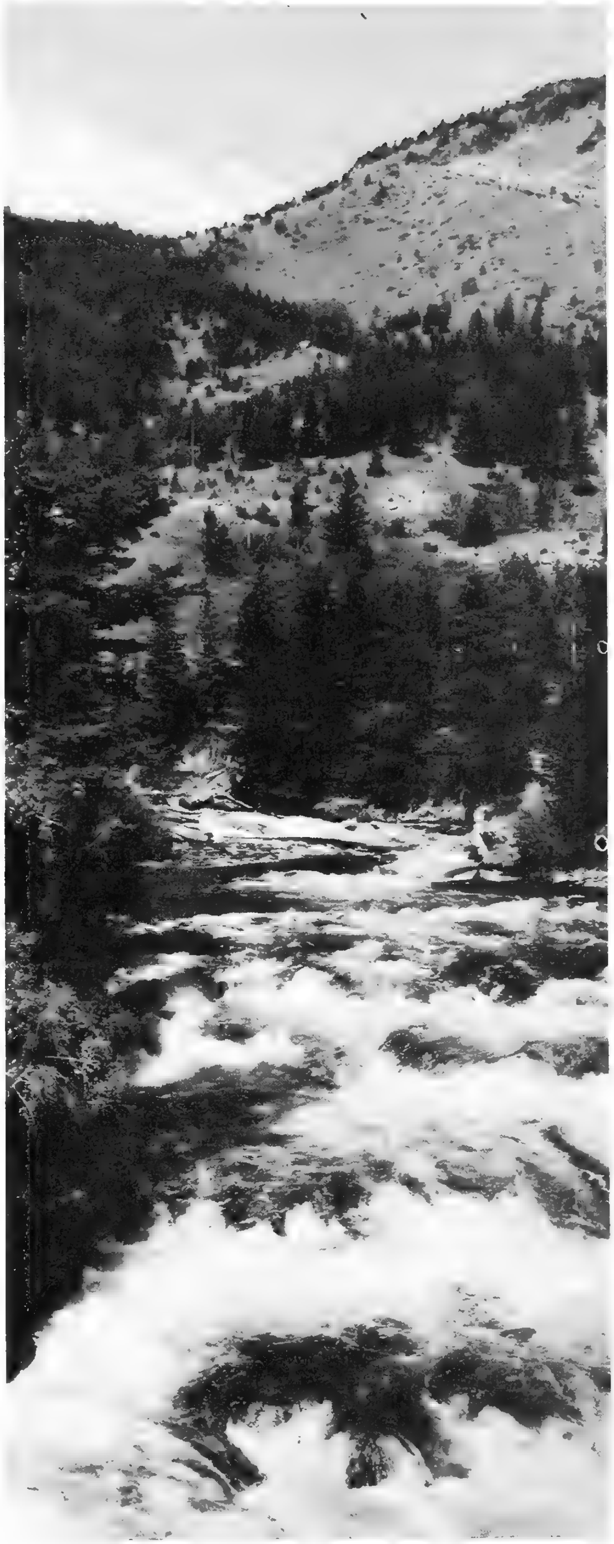
When wildlife activities fall in this complementary part of the total scale, more can be done with a given budget.

Unfortunately, there are few direct opportunities to directly improve the production of fish as a spinoff of timber harvesting or range use. Instead, multiple-use management for fish means avoiding damage from activities on the land, including avoiding the removal of streamside vegetation, physical damage to streambanks, excessive siltation, and the introduction of debris into water channels. Many streams that have been degraded in the past have the potential to once again become productive habitat for fish through natural processes if they are adequately protected. This process can be accelerated through management practices ranging from planting trees on streambanks or in denuded areas to mechanically altering a streambed.

The maintenance of critical water levels through damming for both waterfowl and fish is an example of an activity that works to the advantage of several species. More often, changes in habitat conditions will favor some species and work against others. This is another sort of trade-off. A delicate balancing is sometimes necessary to simultaneously enhance habitats for species that require, say, mature forests and for species that prosper in openings.

Endangered and threatened species. — Enhancement activities directed at endangered and threatened species vary widely because this designation includes dissimilar fauna. For some of these species, notably those restricted to limited areas, management consists of preserving the available habitat and protecting it from disruption. It is sometimes possible to extend restricted or depleted ranges by transplanting animals to presently unoccupied or newly developed habitats. Erecting artificial nests, incubating eggs, and eliminating competitor species might each be applicable in a particular instance.[39]

These species have been a major focus of attention of all Federal land managing agencies. Substantial efforts have been necessary to plan, conduct, and monitor land management activities in a manner that meets the requirements and the spirit of the Endangered Species Act. Significant budget expenditures, increased planning time to allow for consultations and coordination, and delays and occasional reductions in the production of other resources will continue to be necessary to adequately protect or enhance these animals.



The management of forest and range land for fish largely means avoiding damage from timber harvesting and grazing activities.

[39] See, for example, U.S. Department of the Interior, Fish and Wildlife Service. Puerto Rican parrot on the upswing. Endangered Species Tech. Bull. 4(1):4-5. 1979.

Large mammals. — Many large mammals require some sort of relatively dense cover for security and edges or openings for feeding. Those that migrate also frequently require corridors of cover between summer and winter ranges or extensive open ranges.

Major considerations in managing habitat for selected species are listed below:

Species	*General considerations in management*
White-tailed deer	Flourish in second-growth, discontinuous forests managed under short rotations. Mixture of hardwoods and softwoods preferred. Timber harvesting in old-growth forests beneficial. Winter range can be limiting in West.
Elk	Require nearly continuous corridors of mature timber on migratory routes for cover. Because winter range is generally limited in extent, improving forage production on winter range is critical.
Antelope	Domestic livestock can be serious competitors for forage on heavily grazed lands. Pass-through range fencing necessary to allow free movement. Transplanting is occasionally valuable.
Javelina	Brush encroachment on heavily grazed southwestern ranges provides habitat. Most practices that encourage grasses are detrimental.
Bighorn sheep	Major problem is limited suitable habitat. Transplanting to unoccupied areas has been successful. Contact with domestic sheep should be minimized to minimize transfer of parasites.
Black bear	Generally require large blocks of forest interspersed with grasslands. Some timbering and grazing is tolerable. Confrontations with humans frequently lead to eradication or transplanting.
Moose	Require willow bottom riparian habitats for overwintering, but can destroy food supply if not controlled. Controlled burning is often effective in increasing food supply.
Turkey	Eastern turkeys require hardwood forests with open understories. Rio Grande turkeys are affected by heavy livestock grazing pressures. Merriam's turkeys require both forested uplands and open ponderosa pine stands and minimal disturbances.

Small mammals. — Small mammals include species with a variety of often competing habitat requirements. For example, because squirrels den in older trees, long rotations in timber-producing areas are advantageous. By contrast, rabbits require forests in early stages of succession, so timber harvesting on short rotations is most advantageous.

Several systems have been devised to insure a wide variety of habitats are maintained.[40] Timber management systems that lead to mixtures of newly regenerated areas, and a variety of age classes are necessary. Prescribed burning is probably the most widely-used technique for obtaining desired characteristics of vegetative understories.

Many small mammals depend heavily on the understory vegetation in riparian zones and wetlands. Where those habitats are relatively scarce, as in the Great Plains and Southwest, the understory vegetation has frequently been destroyed by cattle. The most useful first step in management is often simply fencing; attention can then be directed to stimulating plant growth.[41]

The major available example of direct population manipulation is the introduction of the nutria to the United States. This furbearer is now found in at least 14 States and in 1976 yielded furs worth more than $8 million to trappers and fur farmers.

[40] See, for example, Holbrook, H. L. A system of wildlife habitat management on southern National Forests. Wildlife Society Bull. 2(3):119-123. 1974. Siderits, K. and R. E. Radtke. Enhancing forest wildlife habitat through diversity. *In* Trans., No. Amer. Wildl. and Nat. Res. Conf. 42:425-434. 1977. U.S. Department of Agriculture. Wildlife habitats in managed forests — the Blue Mountains of Oregon and Washington. Agr. Handb. 553, Washington, D.C. 512 p. 1979.

[41] See, for example, separate papers by C. R. Ames and by J. P. Hubbard, *In* Johnson, R. R., and D. A. Jones (Tech. Coord.). Importance, preservation and management of riparian habitat. U.S. Department of Agriculture, Forest Service, Gen. Tech. Rep. RM-43. Rocky Mountain For. and Range Experiment Station, Fort Collins, Colo. 217 p. 1977.

Most small mammals and upland game birds, such as the ruffed grouse, require a mixture of cover and openings. Maintaining suitable openings is a major management problem in forested areas.

Waterfowl. — For most waterfowl species, the most critical determinants of abundance are the quantities and qualities of water and wetland habitat that are available. Some species, such as the mallard, demonstrate great adaptability; others, such as canvasbacks, require more specific conditions. Unlike the management of resident game habitat, maintenance or creation of habitat in one area may greatly influence the number of waterfowl in other areas.

The maintenance and enhancement of breeding, migration, and wintering habitats offer possibilities for maintaining waterfowl resources as well as increasing hunting opportunities. Flooding of hardwood bottom lands in the Southeast during the fall and winter, either artificially or through natural flooding, significantly increases the habitat base and carrying capacity for waterfowl.

Return irrigation flows are a vital source of water for migrating and wintering waterfowl, particularly in the arid West. Loss of this water source or increased consumption for industrial and residential uses would have serious impacts on waterfowl. Providing additional water during the dry seasons would significantly increase the habitat base. Other practices for improving food and cover include mowing, prescribed burning, disking, planting, and — on a limited scale — carefully managed livestock grazing.

The Fish and Wildlife Service administers about 4 million acres of migratory bird refuges throughout the four flyways and another 1.4 million acres of small waterfowl production areas located mostly in the glaciated prairie pothole region. As of 1975, State conservation agencies controlled approximately 5 million additional acres of land and water of major value to waterfowl, much of which is open to public hunting. About half of the acreage was State-owned and the remainder under lease or other agreement. About 11,000 private waterfowl hunting clubs controlled, through leases and ownership, more than 5 million acres of waterfowl habitat. Many of these acres provide opportunities to help ensure healthy waterfowl populations through cooperative programs.

One notable milestone in the management and protection of waterfowl and other migratory birds is the 1976 Convention Between the United States of America and the Union of Soviet Socialist Republics Concerning the Conservation of Migratory Birds and Their Environment. This Convention goes a step further in the protection of migratory birds than do similar treaties with Canada, Mexico, and Japan. The treaty with the Soviet Union also:

- generally prohibits disturbance of nesting colonies;
- agrees that both countries will undertake measures necessary to enhance the habitat of migratory birds and will provide immediate warning if pollution or destruction of habitat occurs or is expected; and
- calls for special protection of species in danger of extinction.

Other birds. — As is true for small mammals, the many species of resident and common migrant birds in the Nation have a variety of habitat requirements. In general, the habitat requirements for native nongame birds can be met on forest lands if representative vegetation types, age classes, and forest openings are maintained and interspersed on a management-unit basis. To adequately provide for cavity nesters, some portion must be managed on long rotations and/or some trees not harvested at all. After timber is harvested, to the extent that is feasible, slash should be left on the ground and not chopped or burned.[42]

On range lands, the first concerns are to avoid overgrazing and to minimize the trampling of vegetation near water sources. Periodically resting lands from grazing for at least a year is beneficial. Because grasslands have little vertical vegetative structure, bird populations are usually smaller than on forest lands. Maintaining occasional areas in forbs and shrubs and small trees, rather than converting to pure grass, will lead to the greatest variety of species.

[42] See separate papers by Zeedyk, W. D., by K. E. Evans, R. F. Buttery, and P. W. Shields, and by J. W. Thomas and others. *In* Symposium on management of forest and range habitats for nongame birds. Smith, D. R. (Tech. Coord.). Forest Service, Gen. Tech. Rep. W0-1. 343 p. Washington, D.C. 1975. Also see Whitcomb, R. F. and others. Island biogeography and conservation: strategy and limitations. Science 193:1030-1032. 1976.

Increasing supplies of water and building structures and fences also is often beneficial.

Upland game birds generally require a mixture of cover and openings. Prescribed burning, moderate grazing, logging, and planting food crops are beneficial for bobwhite quail, ruffed grouse, and woodcock. A major management problem at this time in eastern hardwood and mixed hardwood and pine forests is maintaining the forest openings that are gradually closing as the forests age. Large-scale impoundments, the conversion of bottom land forests to croplands and improved pastures, and urban development pose the major threats to these species. By contrast, populations of mourning doves prosper as certain agricultural practices become more intensive.

Recreational demands for these birds have been much greater than could be supported by native wild populations. Three of the most popular game species have been introduced to this country: Ring-necked pheasant, Hungarian partridge, and chukar partridge. There are extensive programs by which these and other birds are produced artificially and then released or sold to private owners of hunting lands.

Managing Fish Habitats and Populations

The general means available to enhance fish populations are to increase the acreage of fishable waters, to increase the productivity of existing waters, and to supplement wild populations with hatchery-produced fish.

Increasing acreage of fishable waters. — In 1965, a State-by-State inventory showed about 82 million acres of fresh waters in the United States capable of supporting fish. Aside from the Great Lakes, this total included about 6 million acres of cold waters and 24 million acres of warm waters in the contiguous 48 States. By the year 2000, it was expected that the total acreages of these cold waters should be increased by about one-quarter and warm waters by about one-third (table 4.19). Essentially all increases would be in new impoundments, particularly of public reservoirs and privately-owned farm ponds. About 300,000 acres of streams would be lost through inundation following reservoir construction.[43]

[43]U.S. Department of the Interior, Fish and Wildlife Service. National survey of needs for hatchery fish. Resource Pub. 65. Washington, D.C. 1968. The estimates for 1965 are 16 percent higher for warm waters and 2 percent higher for cold waters than those reported by the Outdoor Recreation Resources Review Commission in 1962. That earlier report suggested that 10 million more acres would be needed by 2000 if future anglers were to have the opportunities available to anglers in 1960; the 1968 report suggested that target would be met.

Table 4.19 — *Fishable freshwaters of the United States in 1965 and projections to 2000*

(Million acres)

Category of water	Year		Change
	1965	2000	
Total fishing waters	81.6	91.7	10.1
Great Lakes	38.7	38.7	
Alaska	12.4	12.4	
Other	30.6	40.7	10.1
Total fishing waters	81.6	91.7	10.1
Warm waters[1]	27.4	36.1	8.7
Cold waters[1]	54.2	55.6	1.4
Public fishing waters	78.7	87.2	8.5
Streams and rivers	9.5	9.2	-0.3
Other	69.2	78.0	8.8
Private fishing waters	2.9	4.6	1.7
Farm ponds	2.2	3.7	1.5
Other	0.7	0.9	0.2

[1]Cold waters are generally defined as those that can support salmonids and warm waters as those that cannot. About 7 million acres categorized as cold water can, in fact, also support warmwater species and 0.3 million acres categorized as warm water can also support coldwater species.

Source: U.S. Department of the Interior, Fish and Wildlife Service. *National survey of needs for hatchery fish.* Resource Pub. 63. 71 p. Washington, D.C. 1968.

In 1960, about three-quarters of all impounded water surface acreage in the contiguous States was in reservoirs larger than 500 acres. From 1970 to 1976, nearly 500 new reservoirs of this size-class were completed, increasing the total surface acreage by half, from 6.5 to 9.8 million acres.[44] The 1976 distribution of these reservoirs across the Nation was:

Section	*Millions of acres*
Northeast	0.5
North Central	0.8
Southeast	0.9
South Central	4.0
Rocky Mountains-Great Plains	2.6
Pacific Coast	0.9
Total	9.7

[44] Jenkins, R. M., U.S. reservoir inventory. U.S. Department of the Interior, Fish and Wildlife Service, National Reservoir Research Program. (mimeo) Fayetteville, Ark. 1976. A reservoir is here defined as an impoundment with a mean annual pool of 500 acres or more; natural lakes regulated by a dam are included if the original volume of water has been at least doubled.

A substantial number of smaller fishing lakes have also been constructed or restored over the years. For example, $30 million in cooperative Federal-State funds have been spent in the last 25 years to create 38,000 acres of fishable waters. About half this acreage is in the South Central and Great Plains sections.[45]

Making it possible for anadromous fish to travel up streams has the effect of creating new spawning and rearing habitat for them. In the contiguous States, this generally has included removing debris, screening pipes that are used to withdraw water for various purposes, and ensuring that fish ladders or passageways are included in structures intended to develop water resources. While these activities are becoming more common in Alaska, the major efforts there are in extending natural habitats by ensuring access to streams not previously available to salmon. Current efforts to restore Atlantic salmon runs in the Northeast include artificial propagation and habitat improvement, as well as creating passageways past existing dams to spawning and rearing areas.

Increasing productivity of waters.—Intensive management techniques are most highly developed for enclosed bodies of water. Undesirable species are poisoned or removed from ponds and small lakes or reservoirs and replaced with desirable species, often in conjunction with the construction of structures that regulate water levels. Other techniques include fertilizing to stimulate food production and installing nesting and rearing cover.

Relatively new Federal and State laws designed to reduce the pollution of the Nation's waters will undoubtedly increase the productivity for fish of many rivers and streams. For example, the Colorado State Division of Wildlife has estimated that water quality improvement could increase the proportion of streams capable of sustaining trout populations in the State by 30 percent. To the extent that pollution is concentrated in and near urban centers, reductions in pollution can be expected to increase fishing opportunities where demands are greatest while reducing travel costs for many users.[46]

Increasing hatchery production.—A substantial share of the freshwater and anadromous sport and commercial fish caught in the United States are produced in hatcheries and then stocked in fishing waters. In 1965, a survey of likely future hatchery capacities and stocking needs to maintain reasonable catches by anglers of trout and warmwater fishes indicated that about 90 percent of requirements might be met in 2000 (table 4.20). The southern States were expected to have the greatest difficulty in meeting requirements for trout, and the south-central and western States the greatest difficulties in meeting requirements for warmwater species.[47]

Private hatcheries were expected to continue to supply 3-4 percent of the trout and 1-2 percent of the warmwater fishes. There were expected to be changes in the proportions of fishing waters that are stocked:

Type of water	*Estimated in 1965*	*Anticipated in 2000*
Public lakes & streams	34 percent	21 percent
Public reservoirs	55 percent	66 percent
Private waters	11 percent	13 percent

For both categories of fish, these projections may be overoptimistic because they do not consider the sizes of fish that will be required in the future. In 1965, the greatest shortages occurred in producing "catchable" fish. To the extent that urban-related reservoirs and put-and-take fishing continue to increase in popularity, there will be a greater demand for these relatively large (and expensive-to-produce) fish.

In 1970, it was estimated that taking advantage of all opportunities to increase hatchery production and to upgrade the productivity of rivers and streams in the Northwest and Alaska could increase total salmon production by half by the end of the century. The programs that seemed most likely to be implemented promised about a 10 percent increase in salmon production.[48]

In 1978, planned hatchery expansions and other activities were the bases for estimates that the production of adult salmon and steelhead available to Washington State commercial and recreational fishermen would be increased by one-half or by about 5.5 million adult fish per year within a decade. Additional

[45] Massmann, W. H. Accomplishments under the Federal aid in fish restoration program, 1950-1975. United States Department of the Interior, Fish and Wildlife Service, Washington, D.C. 37 p. 1976.

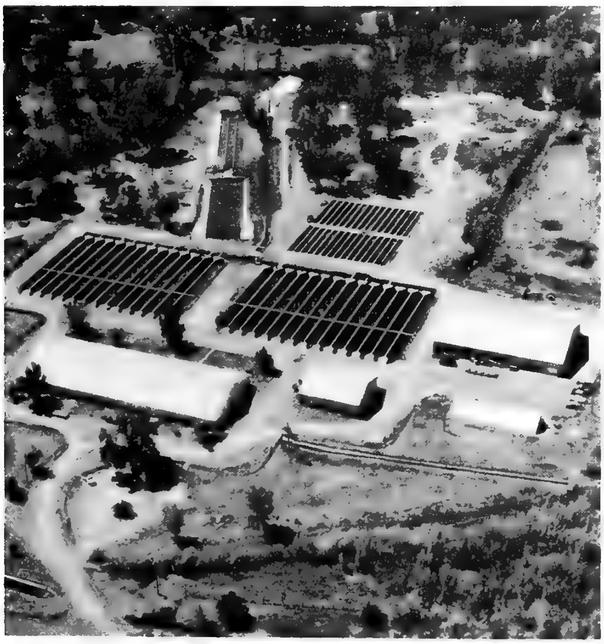
[46] Walsh, R. G. Recreational user benefits from water quality improvement. *In* Outdoor recreation: advances in application of economics. Hughes, J. M. and R. D. Lloyd (comp.), U.S. Department of Agriculture, Forest Service Gen. Tech. Rep. WO-2. Washington, D.C. p. 121-132. 1977.

[47] U.S. Department of the Interior, Fish and Wildlife Service. National survey of needs for hatchery fish. Res. Pub. 63. 71 p. Washington, D.C. 1968.

[48] U.S. Department of Commerce, National Marine Fisheries Service. Basic economic indicators: Salmon, 1947-72. Current Fisheries Statistics No. 6129.p. 33. Washington, D.C. 1973. Also see U.S. Department of Commerce. A marine fisheries program for the Nation. (Statement of Secretary of Commerce). Washington, D.C. 74 p. 1967.

Improvements such as fish ladders around dams let anadromous fish travel upstream to spawn.

Increasing hatchery production is one way of meeting growing demands for fishing.



efforts could add another 6.0 million adult fish annually within 10 years (at least doubling the State's current harvest) at a cost of at least $70 million in (largely Federal) capital investments and operation and maintenance costs of $7 million per year.[49]

Several of the major success stories in meeting recreational demands for fishing are due to the ability of some anadromous species to prosper when restricted to freshwater. Initially, striped bass were restricted to Atlantic and Gulf coastal waters. In the late 1800's, they were introduced to the West Coast and subsequently to inland areas. They are now found in 38 States.[50]

To balance such spectacular success stories, there have been many more attempts that have failed. Transplanting living organisms is always a gamble, as it the artificial propagation of fish. Hatchery production is generally most valuable when used to supplement wild populations for relatively brief periods.

[49] Merkel, J. C., D. L. Alverson, and J. H. Hough. Settlement plan for Washington State salmon and steelhead fisheries. Regional Team of the Federal Task Force on Washington State Fisheries (Dept. Justice, Commerce, and Interior). 348 p. Washington, D.C. 1978. The proposal also calls for certain stream enhancement, research, monitoring, and regulatory activities.

[50] Massmann, *op. cit.*

Table 4.20. — *Capacities of fish hatcheries to produce trout and warmwater fish in the contiguous United States and the relationships to production requirements by section, 1965 to 2000*[1]

Section	Capacity		Capacity as proportion of requirements		
	1965	2000	1965	1980	2000
	Millions of fish		*Percent*		
Trout					
Northeast	23	37	111	115	115
North Central	16	45	109	85	85
Southeast	4	7	96	83	70
South Central	3	8	34	37	28
Rocky Mountains and Great Plains	110	204	104	106	104
Pacific Coast	93	196	100	93	92
Total	249	497	101	96	93
Warmwater species					
Northeast	367	511	77	98	98
North Central	483	891	88	87	88
Southeast	91	92	89	90	88
South Central	89	179	16	57	67
Rocky Mountains and Great Plains	158	296	85	76	79
Pacific Coast	1	4	15	55	59
Total	1,189	1,973	63	85	86

[1] In 1965, 90 percent and 47 percent of the requirements for catchable trout and warmwater species, respectively, were produced.
Source: U.S. Department of the Interior, Fish and Wildlife Service. *National survey of needs for hatchery fish.* Resource Pub. 63. 71 p. Washington, D.C. 1968.

To produce a sustainable increase in the numbers of fish usually requires that the fish-producing acreage or carrying capacity be increased. The fact that hatchery operations are sometimes desirable suggests the preservation of wild populations and their habitats has substantial economic values.[51]

Managing Wildlife and Fish Use

Given the many increasing demands on our wildlife and fish resources, opportunities to manage use are being more and more viewed as needs to limit use. More people participating means a change in the type of recreational experience. In the years to come, either the numbers of people permitted to use the resources will be limited, or crowding and lower success ratios will follow.

Sportsmen who wish to hunt several big game species in some areas already must take their chances with lottery systems, particularly for elk, moose, mountain goats, bighorn sheep, and antelope. For other species, limits on season takes have become more restrictive. These limitations are likely to continue to be necessary but they can sometimes be relieved by applying good habitat and population management practices more extensively.

It has long been the custom to require licenses for hunting and fishing, with the receipts used to enforce regulations and to fund activities for improving habitat and population. One approach that has been frequently discussed, both to provide more adequate funding and to limit use, is to increase basic license fees or to add a surcharge for hunting in particular areas. This issue is politically volatile and each proposal has encountered opposition, primarily on the grounds of equity, concern for impacts on total receipts, and Federal-State jurisdictional disputes.[52]

Much higher levels of nonconsumptive uses are possible in most parts of the Nation. Meeting such demands generally amounts to providing nondestructive access and publicizing opportunities for wildlife observation. In undeveloped areas, new trails often can be constructed at low cost, perhaps with self-guiding signs, and when one area is overused, others can be publicized. However, because most wildlife observation takes place near where people live, meeting nonconsumptive demands frequently requires providing permanent, hardened trails and sites in or near urban areas.

The general problem of limited access to private lands is discussed in the next section, but this problem also is important on public lands. In some instances, access must be limited to protect the wildlife and fish resources or to protect fragile areas from physical degradation. In other instances, improved access is possible. In the past 25 years, 800,000 acres of stillwaters and 2,000 miles of free-flowing streams have become available for fishing through the purchase and development of access sites.

Opportunities for Cooperative Activities on Private Lands

Privately-owned forest and range lands play a major role in providing key habitats for waterfowl and in providing opportunities for hunting — especially for small game mammals, upland game birds, and waterfowl — and for warmwater fishing. In heavily farmed areas, particularly in the Great Plains, fence rows and shelterbelts on private lands fre-

[51] Opportunities and problems associated with the artificial propagation of salmonids are discussed by Cooper, E. L., E. O. Salo, and H. Tanner. Salmonid management. Trout 15(1): Special supplement, 32 p. 1974.

[52] Hoover, R. L. User fees for hunting and fishing on public lands. Publications DOW-RM-M-6-78, Colorado Division of Wildlife, Denver, 65 p. 1978.

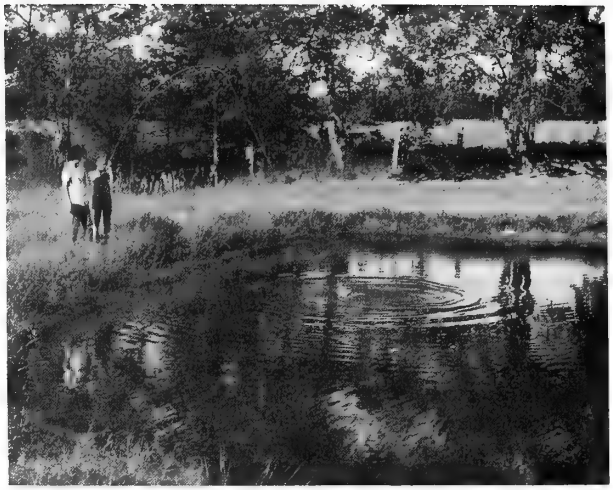
quently provide the principal habitat over relatively large areas for a number of species of birds and small mammals.

Past efforts of private groups and public agencies have improved conditions for wildlife and fish and have helped increase opportunities for use of these resources on private lands. Conservation groups such as the Audubon Society, Nature Conservancy, Isaak Walton League, and The Wildlife Federation have worked at national and local levels to foster protection and improvement of fish and wildlife habitat. Organized groups of hunters and anglers have helped increase the general awareness of the values of these resources and have been sources of income to landowners. Some States directly compensate farmers for damages to their crops by big game and some provide relatively low tax rates for critical habitats, particularly for wetlands. Federal, State, and local levels of government have provided general education and limited technical assistance and cost-sharing programs.

But much more could be done. Numerous surveys have shown that landowners often regard the enjoyment of wildlife as a major benefit of owning a few acres of land. There are inexpensive options for attracting more wild animals available to most of these owners. Leaving selected trees and shrubs when clearing land, allowing weeds to grow along fences, modifying harvest practices to favor certain types of trees, and creating openings in woodlots all can greatly improve conditions for a wide variety of birds and small mammals.

Limited access to private lands remains a major complaint of sportsmen. But lands are posted against public use for many reasons, including the very real threat of claims for liability if recreationists are injured. Several States have passed laws that partially relieve landowners of liability not involving negligence when hunters and fishermen use their property. Some insurance companies provide policies for hunting and fishing use, but most landowners do not know about them. Such options for protection against liability could be improved and expanded and publicized more effectively.[53]

Even when liability and other problems such as littering and vandalism are overcome, it is still unreasonable to expect owners to open their lands unless they are adequately compensated. This frequently requires informing owners about the possibilities for establishing a business and then setting up some mechanism to help them get started.



Technical and financial assistance for increasing and improving habitat on private lands can contribute to meeting the growing demands on wildlife and fish resources.

A number of wood-products companies in the South (where there is relatively little public land) have been successful in converting the wildlife and fish on their lands into cash crops by charging a daily use fee or selling seasonal leases on hunting and fishing rights. Some of these firms have entered into agreements whereby State wildlife agencies are responsible for wildlife management. Examples of profitable fish and wildlife-centered operations could be publicized and technical assistance provided to landowners to get them started.

To help owners of smaller tracts of land, several State agencies also have programs for game and fish management in which they manage aggregations of private tracts for hunting and fishing. Recreationists purchase annual hunting or fishing permits and the landowners receive a portion of the receipts. Such programs could be made more generally available.

Since the second World War, many farm ponds and other impoundments have been improved for fishing, but little attention has been paid to the thousands of miles of small warmwater streams on private lands. Similarly, little attention has been paid to the control of predators or to animal damage on private ownerships in the East. As on public lands, coyotes and free-running dogs occasionally pose problems for deer and other wild animals. Porcupines seriously damage trees in particular areas. And through their dam building and subsequent flooding of nearby lands, beavers can have a devastating local impact on timber management programs and destroy bottomland hardwoods that provide key habitats for other species.

[53] See the chapter on outdoor recreation in this report for a more complete discussion of the extent and reasons for closures of private lands to hunters, anglers, and other recreationists.

Historically, most Federal-State cooperative technical assistance and cost-sharing programs directed at landowners have concentrated on one or two commodity products. These programs also provide a ready vehicle for informing owners about wildlife enhancement opportunities when considering forest, range, and agriculture management practices.

Landowners usually do not know that standard commodity practices can be modified to help protect and enhance wildlife, often at low cost. Relatively minor changes in the location, intensity, and timing of land treatments can often be valuable. For example, if fall plowing is limited, waste grain or green grass shoots can attract more waterfowl. As was previously mentioned, other practices that can sometimes be used to improve wildlife food and cover including mowing, disking, planting, and carefully controlling livestock grazing.

On lands that support commercially valuable timber, attention to how timber harvesting is carried out can often improve the wildlife carrying capacity of the land by providing more food and cover. Unfortunately, even when options are generally understood, landowners frequently do not really know where to turn for technical assistance for multiresource planning and implementation. To take full advantage of such opportunities, agencies and other organizations would have to improve coordination of technical assistance and information programs substantially.[54]

In addition to direct assistance programs, lands have also been bought outright by conservation groups and public agencies to ensure preservation of key habitats, most notably for waterfowl in the northern Great Plains. Easements have been purchased to provide an economic incentive to landowners to not drain, burn, or fill wetlands, while allowing use of those areas for grazing, haying, and cultivation in the dry season. The Fish and Wildlife Improvement Act of 1978 recently provided for continuing purchases of such "conservation easements."

In general, at least the costs of improving habitat conditions or providing recreational opportunities must be covered if private landowners are to become interested in such activities. While public ownership is needed in some instances to protect key habitats, most wildlife- and fish-related recreational opportunities will continue to be on private lands, simply because there are more private than public lands.

Opportunities for Research

The ability to satisfy future demands for the market, social, and ecological values of wildlife and fish associated with forest and range lands will continue to depend on the understanding of those resources and progress in translating that understanding into a form that can be used by those who decide on budgets and by on-the-ground managers of land and water resources.

In recognition of the rapid changes occurring in the resource base, recent State and Federal legislation has accelerated planning processes that will largely determine conditions for many years to come. For example, the National Forest Management Act of 1976 requires that intensive land and resource management planning be completed on all National Forests by 1985. To the extent that critical information on wildlife and fish resources is not available, it is likely that the activities that follow planning will be less effective than they could be.

During late 1977 and early 1978, a series of workshops were held throughout the United States to define the major research needs related to forest and range lands. The following were rated as the subjects needing top priority in research programs concerning wildlife and fish:

- Evaluate the effects of prescribed burning techniques, silvicultural practices, and livestock grazing systems on water quality and on wildlife and fish habitats; develop improved management alternatives where advantageous.
- Develop multiple use management strategies for aquatic and associated riparian ecosystems that will protect, rehabilitate, and enhance wildlife and fish habitats.
- Define minimum habitat conditions needed to maintain populations of various wildlife species.
- Establish a system for placing quantitative values on such non-marketed forest and range resources such as wildlife.
- Determine the impacts of wilderness designation and of general recreation activities on the future abundance and diversity of wildlife.

[54] The need to improve coordination among public assistance programs was a frequent comment received during public review of the draft of this assessment document. The owners of relatively small acreages still face a variety of practical problems even when they have the desire to invest in their lands and when adequate technical assistance programs are available. These problems include diseconomies of small scale, difficulties in hiring skilled labor, and difficulties in acquiring investment capital. For discussion of the problems and the approaches available for overcoming them through cooperative programs among public and private groups, see: U.S. Department of Agriculture. The Federal role in the conservation and management of private nonindustrial forest lands. Washington, D.C. 63 p. plus appendices. 1978.

The selection of these and other topics and experience gained in assembling this document suggest more comprehensive information and improved analytical techniques are needed to better describe the status of wildlife and fish resources, to define effective and efficient management strategies to improve that status, and to evaluate those strategies to ensure the most effective activities receive the highest priorities under limited budgets.

Except for a few recreationally and commercially important species, little quantitative information is available on either the demand for or supply of wildlife and fish populations. The only widely available information concerns the numbers of licenses sold to hunters and anglers and the numbers of animals and fish harvested. No State believes it has credible information of this type for more than 40 species; most are comfortable only when speaking to half that number. Credible estimates of statewide population levels are still rarer, and estimates of the numbers of nonconsumptive users are fragmentary at best. More complete information is available for some much smaller areas, but it probably never includes more than a small fraction of the entire spectrum of fauna. In many areas, available information is inadequate to allow a complete list of vertebrate species to be compiled.

These kinds of data are needed simply to monitor what people want and the present conditions of wildlife and fish, so that the greatest needs for management programs to correct unsatisfactory conditions can be identified. Identifying programs that will be of the greatest benefit in the future requires projecting demands and populations and the availability of those populations to users. At this time, projecting demands for these resources is almost entirely a matter of personal judgment; the understanding of the determinants of demand is still rudimentary.

The state of the art of projecting population levels is relatively advanced for a few species of importance to consumptive users. Unfortunately, traditional approaches for dealing with one species at a time have two major drawbacks: the process is so expensive and slow that serious attention is seldom focused on "minor" species and little information is gained about the interrelationships within faunal communities. Current work in developing "species profiles" as a basis for grouping species by similar habitat requirements promises to allow at least first-order projections of the conditions of entire faunal communities within the near future and to provide a comprehensive basis for more detailed species-by-species analyses that will be needed for improved projections.

A major constraint on projecting wildlife conditions is the dearth of inventory data defining the extent of existing habitats. No comprehensive and quantitative inventory of available habitats exists for any substantial part of the Nation, nor are there a commonly accepted conceptual basis and set of tools for developing such an inventory.[55] To predict conditions and develop management programs oriented to the future, quantitative measurements are needed that can be related to inventory data on other resources. The extent to which habitat measurements can be correlated with existing historical data, and particularly with the relatively extensive information that is available for timber resources, will determine the ability to develop historical trends and projections.

To develop management strategies that are most likely to enhance wildlife and fish in the future, it is necessary to better understand the impacts on wildlife and fish of both major and minor changes in the land and water base. The conversion of forest and range lands to agricultural and urban uses will continue, and it is likely that energy and water-related developments will expand considerably.

What are the quantitative implications of management activities to animal populations? How many more deer or salmon will be produced by following a particular habitat management regime or by limiting consumptive use? With few exceptions, we have little ability to quantitatively predict the consequences of alternative combinations of habitat manipulation and use regulation. Of general concern in the management of terrestrial species are the potential gains and losses of using controlled fire and chemicals and carefully tailored silvicultural and livestock grazing techniques.

Insects, diseases, and wild fires have direct impacts on the vegetation that provides habitat for wildlife and indirect impacts on aquatic habitats. Research is needed to define short-term and long-term consequences to wild fauna and to utilize or compensate for these potentially destructive agents in forest and range land management.

In general, good management strategies are those that lead to desired conditions most quickly, are economically efficient, place low demands on budgets, and have low negative impacts on other resources. Insuring desirable conditions for wildlife and fish populations frequently imposes constraints on the uses of other resources. Because such constraints imply very real costs, research is needed to set those

[55] Hirsch, A., W. B. Krohn, D. L. Schweitzer, and C. H. Thomas. Trends and needs in Federal inventories of wildlife habitat. *In* Trans. No. Amer. Wildl. and Natur. Resource Conf. 44:267-284. 1979.

constraints as precisely as possible so that neither excessive safety margins nor inadequate guidelines dominate. Where management techniques affect only wildlife or fish resources, the major need is to develop cost-effective approaches.

What is the expected gain from spending dollars in different ways? If the physical consequences of expenditures can be predicted, what are the social and economic implications? Such questions are relevant to those who must decide how limited funds are to be distributed among many apparently worthy possibilities. The state of the art in conducting such evaluations of programs centered on wildlife and fish resources is far behind that concerning commodity values because the nonmarket aspects make it a more demanding task, and because the resources devoted to making such evaluations have never approached the scale of the many efforts to evaluate water developments, timber harvesting, and similar activities. Expressing ecological values in a manner that is comparable to market values of commodity resources is particularly difficult.

There is also a need to define the values of tradeoffs. As recognized in the Fish and Wildlife Coordination Act, it is appropriate to charge certain mitigation costs for wildlife and fish to water resource development projects. Similarly, it may also be appropriate to charge foregone values due to restrictions on timber harvesting along streambanks to local fisheries. In such cases, foregone values should be charged as costs against the anticipated gains of implementing a particular management strategy if reasoned decisions are to be made.

As the pressure for a wide spectrum of goods and services from forest and range lands increases, the need for more comprehensive information on the full range of wildlife and fish species will intensify.

Chapter 5. — Range

The Nation's Range Base

This chapter includes (1) a description of the range resource base, its distribution, ownership, condition, utilization, and management; (2) a discussion of the demand for range grazing by livestock as influenced by national demands for meat and fiber; (3) projections of the supply of range grazing; (4) demand-supply relationships; and (5) the opportunities and research needed for improving and managing the range resource to increase supplies of range grazing. The discussion concentrates on the use of forests and rangelands for livestock grazing. Other products and uses, such as wildlife, water, recreation, and timber and their interactions, are discussed in other chapters in this report.

The material presented here relies heavily on the conceptual framework and issue delineation of "The Nation's Range Resources — A Forest-Range Environmental Study,"[1] "Opportunities to Increase Red Meat Production from Ranges of the United States,"[2] and "The Nation's Renewable Resources — an Assessment."[3] Many agencies and many people cooperated in developing the resource data and providing information about condition and productivity of the range resource.[4]

Definition of range. — Range is land that provides or is capable of providing forage for grazing or browsing animals. It includes all grasslands and shrublands (collectively called rangelands) and those forest lands that will continually or periodically, naturally or through management, support an understory of herbaceous or shrubby vegetation that provides forage for grazing and browsing animals. Also included are those lands that have been seeded to nonnative plants but are managed as if the species were native.[5] The pinyon-juniper and chaparral-mountain shrub ecosystems, classed as other forest land in the chapter on Forest and Range Lands, are included in rangelands in this chapter because their responses to range management principles and practices are similar to those of shrubland ecosystems.[6] Lands designated as improved pasture, cropland pasture, and grazed cropland are not included in the range base used in this assessment because they are routinely cultivated, seeded, fertilized, or irrigated.[7]

Description of the range. — A complex array of 54 ecosystems, characterized by a variety of vegetation life forms, makes up the Nation's range base. More than half the range area is dominated by grasslands and shrublands and the balance by coniferous and deciduous forests. In the Pacific Coast area, the rangeland ecosystems are characterized by annual grasses, bunchgrasses, sagebrush, chaparral, and mountain meadows while the forests are primarily coniferous. The arid and semiarid ranges of the Southwest and the Intermountain Great Basin area are dominated by a complex of bunchgrasses, annual grasses, cacti, salt-tolerant shrubs, sagebrush, pinyonjuniper, and chaparral. A mosaic of sagebrush, grasslands, meadows, aspen, and conifers makes up the rangelands and forests of the Rocky Mountains. East of the Rockies are the Great Plains ecosystems characterized by short grasses and midgrasses and low shrubs on the western part of the plains, and by tall grasses, shrubs, shinnery, and savanna on the eastern edge. East of the 95th meridian, forest ecosystems dominate the landscape with only remnants of prairie and wet grasslands.

Distribution

When the Europeans first colonized what is now the United States, virtually all of the 2.255 billion acres of land were forests or rangelands. As settlements occurred, first in the Southwest in the early 1500's and later in the East, forests and rangelands were converted into cropland and pastureland to provide food for the people and forage for livestock. Later, towns, cities, highways, railroads, mining, and other industrial activities further encroached upon the forests and rangelands. By 1976, about 1,557 million acres, or 69 percent of the Nation's land area, remained as forests and rangelands (table 2.1). In the lower 48 States, 64 percent of the land area remains

[1] U.S. Department of Agriculture, Forest Service. The Nation's range resource — a forest-range environmental study. Forest Resource Rep. 19, 147 p., illus. 1972.

[2] U.S. Department of Agriculture, Interagency Work Group. Opportunities to increase red meat production from ranges of the United States. Washington, D.C., 100 p. 1974.

[3] U.S. Department of Agriculture, Forest Service. The Nation's renewable resources — an assessment, 1975. Forest Resource Rep. 21, 243, p., illus. 1977.

[4] Data on non-Federal lands were provided by the Soil Conservation Service and by State agencies. Data about the Federal lands were provided by the Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, Forest Service, National Park Service, and the Department of Defense. In addition, more than 200 people from Federal and State agencies and universities participated in four workshops. They developed production coefficients and estimates of range potential.

[5] Adapted from the Glossary of range terms used in range management, Society for Range Management, 32 p. 1964.

[6] The pinyon-juniper and chaparral-mountain shrub ecosystems occupy 62,782,000 acres in the 17 western States (table 2.8). Therefore, in this chapter, total forest area is short and total rangeland long by that amount as compared to forests and rangelands in the chapter on Forest and Range Lands.

[7] These lands were classified according to accepted definitions and standards developed by the Soil Conservation Service and are included in "other lands," table 2.1.

occupied by forests and rangelands and 73 percent in the 17 western States (fig. 5.1).

Each State still has a significant proportion of its total land area classified as forests or rangelands (figs. 2.2 and 2.3). Alaska has the largest proportion, 97 percent. Even the highly industrialized and densely populated States of the Northeast such as Pennsylvania, New York, Massachusetts, and Connecticut still have well over half of their respective land areas occupied by forests. Only in North Dakota, Iowa, Illinois, Indiana, and Ohio do forests and rangelands occupy less than 30 percent of the land area.

The forests and rangelands of Hawaii and the island territories and possessions, while important locally (e.g., 72 percent of Hawaii is either forests or rangelands), make up less than 0.5 percent of the Nation's range base.

The location and distribution of the forests and rangelands influence the uses made of them, especially with respect to livestock grazing. Where rangelands and forests occupy much of the land area, livestock grazing is almost always an important use of the land. Often it is the major use. In those areas, range grazing and the activities associated with it attain a local and even regional importance, economically, socially, and culturally, that may far transcend its importance from a broader standpoint.

Most people commonly think of livestock grazing in the 17 western States when the Nation's range and its resources and uses are discussed. There is good reason for this thinking. Ninety-nine percent of the 650 million acres of rangeland in the contiguous 48 States and 37 percent of the forest lands are in these States (fig. 5.2). Only 1 percent of the rangelands, mainly remnants of the prairie and wet grassland ecosystems, are in the eastern 31 States and most of that is in the South.[8] Although the eastern States do have the bulk (63 percent) of the forest lands, only a small portion of those lands is grazed. They do, however, have a potential to make a greater contribution to the Nation's forage supply through conversion of forest to improved pasture.

Ownership

Non-Federal owners control over three-fourths of the forest lands and almost two-thirds of the rangelands in the contiguous States (fig. 5.3). Except for local zoning ordinances and laws relating to public health and safety, private landowners are seldom constrained by laws or regulations concerning livestock use of their lands. They can use any system of grazing or level of management they desire.

Federal lands, on the other hand, are very directly affected by Federal laws and regulations relating to uses made of the land. The Bureau of Land Management and the Forest Service, the two largest Federal land managing agencies, are required to manage the public lands they administer in accordance with multiple-use principles and policies and to maintain

[8] In this chapter, Oklahoma and Texas are included in the Great Plains Region and not in the South as in the other chapters. The physiography, climate, vegetation, soils, and ecological relationships in Oklahoma and Texas are more closely identified with Kansas, Nebraska, South Dakota, and North Dakota than with any other aggregation of States. As a result, the range relationships and interactions concerned with land use, range management practices, economics, culture, and social values are far more similar to Kansas, Nebraska, and the Dakotas than to Louisiana, Mississippi, Alabama, Florida, and the other southern States.

Figure 5.1

Land Area of the United States by Type, 1976

Mil. Acres

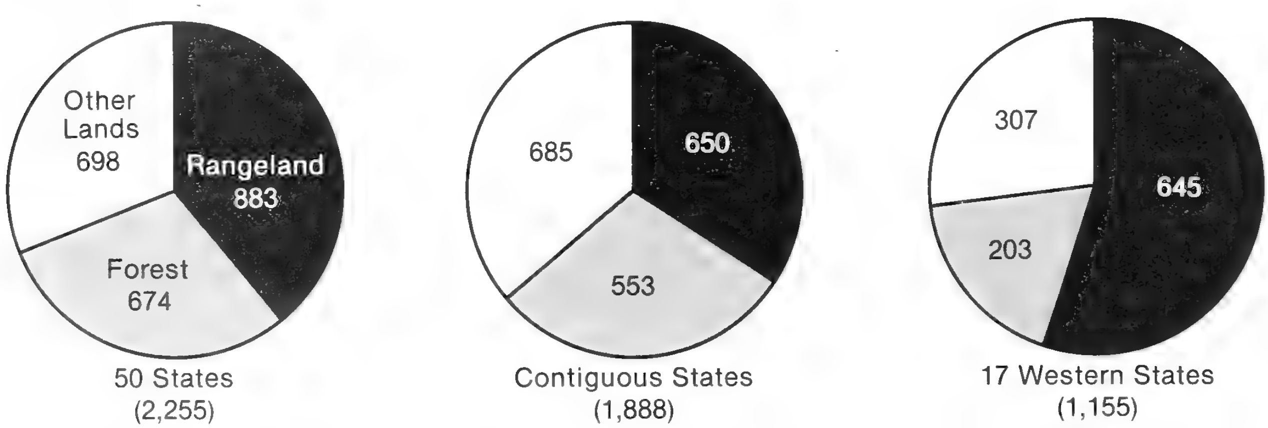


Figure 5.2

Geographic Distribution of Forests and Rangelands in the Contiguous States, 1976

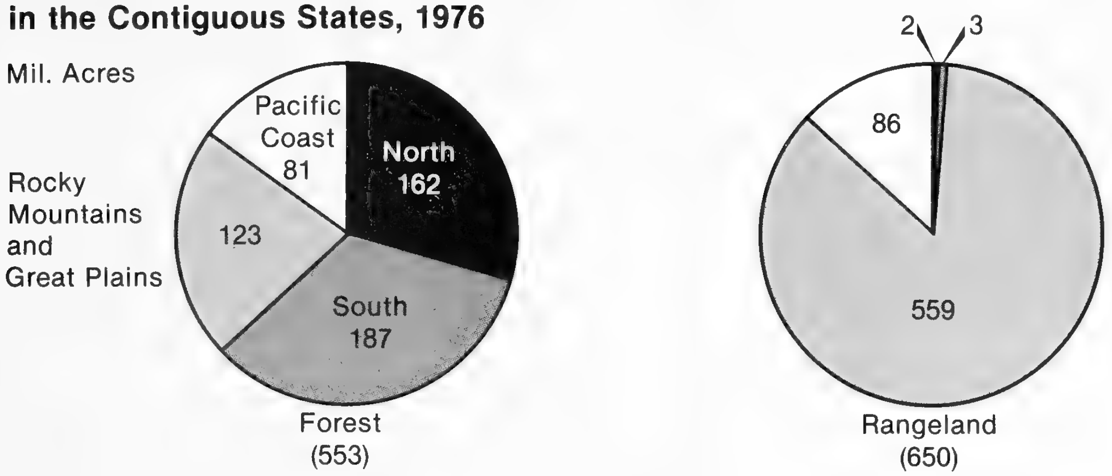
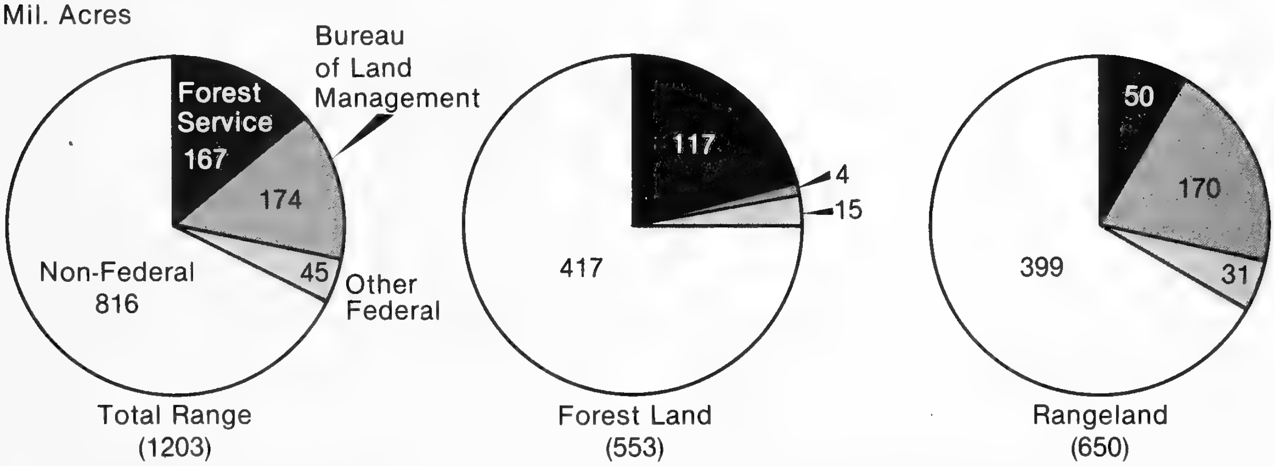


Figure 5.3

Ownership of Range in the Contiguous States, 1976



the productivity of those lands. Livestock grazing is recognized as one of the multiple uses and must be managed consistent with maintaining the productivity of the land. Lands such as national parks, wildlife refuges, and military reservations are administered by other Federal agencies and are not managed for multiple uses, and grazing by livestock is often limited or prohibited. As a result, most of these Federal lands cannot be considered as suppliers of range grazing under present laws and regulations.

Condition of the Rangelands

Many things may affect the productivity of the Nation's forests and rangelands. Natural catastrophes such as wildfires, insect and disease outbreaks, and prolonged droughts can drastically modify the vegetation cover, at least for a short time. Some of man's activities such as timber harvesting, off-road vehicles, concentrated recreational use, and herbicides also modify vegetation and soils. But, of all of man's activ-

ities, grazing by livestock has been the most widespread and prolonged use and has had the most profound effect upon the Nation's ranges.

Most of the Nation's forests and rangelands have been grazed by livestock for well over 100 years — some for over 450 years. Ponce de Leon is believed to have introduced livestock to Florida in 1519. Livestock first trod the arid and semiarid rangeland of the Southwest in 1540 when the Spanish captain general Coronado took with him "1,000 horses and 500 of our cows and more than 5,000 rams and ewes" on his march through Colorado and Kansas in his quest for the fabled seven golden cities of Cibola.[9]

In the eastern States, livestock grazing was an early and important use of the forest land. By 1614, Jamestown Colony, Virginia, was ". . . furnished with two hundred neate cattell, as many goates, infinite hogges in heards all over the wood . . .".[10] By the middle of the 1600's and early 1700's, herds of wild cattle and horses were considered as troublesome problems in the forested areas of the East Coast.[11]

As settlement of the New World occurred, livestock were moved eastward and northward from the Southwest and westward from the East Coast for the next 200 to 300 years until virtually all rangelands and most of the forest lands that produced forage in the 48 States were being grazed at the beginning of the twentieth century.

Range condition defined. — Range condition is an estimate of the degree to which the present vegetation and ground cover depart from that which is presumed to be the natural potential (or climax) for the site. The natural or ecological potential of a site is considered to be the amount and kinds of vegetation that would exist on the site under the existing climate, physiography, and soils if the effects of man and his agents were removed and natural catastrophes had not occurred. The less the departure in terms of plant species composition, production, and ground cover, the better the condition; the greater the departure in composition or ground cover and the less the production relative to the potential for the site, the lower the range condition. The rating is ecological and provides an effective way to evaluate changes as the result of past or present use.

Some rangelands have been seeded to improved forage grasses and legumes, but are managed as if the vegetation were native and agricultural practices such as cultivation, fertilization, irrigation, etc., are not routinely employed. Condition of such ranges is based upon comparing present production and ground cover with that expected for the site. The more closely present production and cover are to potential for the site, the better the condition.

Classification — For this Assessment, rangelands were rated into four condition classes — good, fair, poor, and very poor — depending upon the degree of departure of the present vegetation from the ecological potential of the site.[12] Good condition rangelands are those on which the present vegetation and soils are between 61 to 100 percent of the potential for the site. Fair condition rangelands are 41 to 60 percent of potential; poor, 21 to 40 percent; and very poor 20 percent or less.

Geographic variation in condition. — More than one-half of the rangelands in the 50 States are judged to be in fair to good condition (table 5.1). However, if the 48 contiguous States are considered separately, only 46 percent of the rangelands are in fair or good condition.

There is a consistent gradient in condition of rangelands in the western States with conditions being judged lowest in the southernmost States and highest in the northernmost. Although no detailed studies have been made, it is reasonable to associate the lower rangeland conditions of the southwestern States with their arid climate, prolonged grazing seasons, and the long history, 400 years, of sustained grazing by livestock. Less than 40 percent of the rangelands in California, Arizona, New Mexico, and Texas are in good or fair condition. In the northern States of Oregon, Idaho, Montana, Wyoming, and North and South Dakota, more than 50 percent of the rangelands are fair or better. The rest of the western States have from 40 to 50 percent of their rangelands in fair or good condition.

[9] Barnes, Will C., The story of the range. U.S. Department of Agriculture, 60 p. 1926.

[10] Hamer, Ralph. A true discourse of the present estate of Virginia. Reprinted from the London edition, 1615 with an introduction by A. L. Rowse, Virginia State Library, 1957. Publ. No. 3. 1615.

[11] Barnes, 1926, *op. cit.*

[12] The philosophical base for judging condition, i.e., rating the present community against the ecological potential, is quite uniform among Forest Service, Soil Conservation Service, and the Bureau of Land Management. There is, however, some variation among these agencies with respect to the number of condition classes and class limits used. For many years, the Forest Service has rated rangelands into five condition classes — excellent, good, fair, poor, and very poor — using 20 percent class limits. The Soil Conservation Service and the Bureau of Land Management have used four condition classes — excellent, good, fair, and poor — with 25 percent class limits. In order to use existing Forest Service data in this Assessment, the five condition classes were reduced to four by combining the excellent and good classes into the good class. The resulting four classes are considered to be essentially equivalent to the four classes used by the Soil Conservation Service and the Bureau of Land Management.

Table 5.1 — *Conditions of rangeland by States in the United States, 1976*

(Thousand acres)

Section, region, and State	Total	Good	Fair	Poor	Very Poor
North					
Northeast					
Connecticut	0	0	0	0	0
Delaware	*	*	0	0	0
Maine	*	*	0	0	0
Maryland	84	6	8	8	62
Massachusetts	*	*	0	0	0
New Hampshire	0	0	0	0	0
New Jersey	60	*	6	6	48
New York	2	2	0	0	0
Pennsylvania	*	*	0	0	0
Rhode Island	0	0	0	0	0
Vermont	*	*	0	0	0
West Virginia	0	0	0	0	0
Total	146	8	14	14	110
North Central					
Illinois	*	*	0	0	0
Indiana	3	3	0	0	0
Iowa	38	8	18	10	2
Michigan	*	*	0	0	0
Minnesota	156	56	45	54	*
Missouri	1,448	120	385	634	309
Ohio	0	0	0	0	0
Wisconsin	7	4	3	0	0
Total	1,652	191	451	698	311
Total, North	1,798	199	465	712	421
South					
Southeast					
Florida	2,189	185	287	460	1,258
Georgia	0	0	0	0	0
North Carolina	0	0	0	0	0
South Carolina	20	18	1	0	0
Virginia	28	19	5	4	0
Total	2,237	222	293	464	1,258
South Central					
Alabama	54	1	12	26	15
Arkansas	*	*	*	0	0
Kentucky	0	0	0	0	0
Louisiana	517	4	459	54	0
Mississippi	20	10	7	1	0
Tennessee	400	16	144	228	12
Total	991	31	622	309	28
Total, South	3,228	253	915	773	1,286

Section, region, and State	Total	Good	Fair	Poor	Very Poor
Rocky Mountain and Great Plains					
Rocky Mountains					
Arizona	58,823	6,928	16,252	25,625	10,018
Colorado	35,228	4,085	10,615	14,536	5,992
Idaho	24,182	4,514	8,673	7,775	3,220
Montana	54,156	8,687	22,127	18,735	4,606
Nevada	62,736	7,839	30,126	19,630	5,141
New Mexico	59,832	6,005	11,548	28,397	13,883
Utah	39,615	7,586	10,170	14,149	7,711
Wyoming	47,608	8,550	17,228	17,388	4,442
Total	382,180	54,194	126,739	146,235	55,012
Great Plains					
Kansas	16,278	1,676	7,317	5,503	1,782
Nebraska	24,274	3,667	7,591	8,401	4,615
North Dakota	12,296	4,048	4,253	2,837	1,157
Oklahoma	9,301	1,048	3,430	3,768	1,055
South Dakota	23,402	3,405	11,050	7,233	1,715
Texas	91,599	12,128	21,209	41,383	16,879
Total	177,150	25,972	54,850	69,125	27,202
Total, Rocky Mountains and Great Plains	559,330	80,166	181,589	215,360	82,096
Pacific Coast					
Pacific Northwest					
Oregon	24,804	4,781	9,249	7,513	3,260
Washington	7,895	1,597	2,195	3,046	1,058
Total	32,699	6,738	11,444	10,559	4,318
Pacific Southwest					
California	53,290	9,365	9,090	17,184	17,651
Total	53,290	9,365	9,090	17,184	17,651
Total, Pacific Coast	85,989	15,743	20,534	27,743	21,969
Total, Contiguous States	650,345	96,361	203,503	244,588	105,891
Alaska	231,471	183,272	43,876	4,323	0
Hawaii	968	343	166	198	261
Total, United States	882,784	279,975	247,545	249,109	106,152

*Less than 500 acres

Note: Totals may not add due to rounding

Less than half of the rangeland in the contiguous States is in fair or good condition.

Nevada is a major anomaly to this latitudinal gradient in range condition with 60 percent of the rangelands being judged in fair or better condition. This relatively high rating of Nevada rangelands is surprising in view of recent concerns expressed about poor range conditions in that State.

Conditions of rangelands in Hawaii and Alaska are generally better than in most of the contiguous States. Slightly more than one-half of Hawaii's 968,000 acres of rangelands are in fair or good condition. Almost all (98 percent) of the rangeland in Alaska is estimated to be in fair or good condition. The high condition of Alaska's rangeland most probably reflects continuation of the cyclic pattern of wild ruminant grazing under which Alaska's rangelands evolved. Estimates made locally indicate that of the lands in the Aleutian Islands that are being grazed by cattle, 65-70 percent are in good condition and 25-30 percent are in fair.

Condition by ecosystem.—In general, the grasslands are in slightly better condition than the shrublands (fig. 5.4), but the differences are not significant. The high-producing, high elevation rangelands—mountain grasslands and mountain meadows—are in much better condition than are the low-producing arid and semiarid rangelands (table 5.2). This may be due to the history and short duration of grazing, ownership patterns, levels of management practices, and, most certainly, the relatively favorable moisture conditions prevailing in these high elevation ecosystems. The favorable growing conditions of the mountain grasslands and meadows enable them to recover fairly rapidly from the effects of past misuse once better management is implemented.

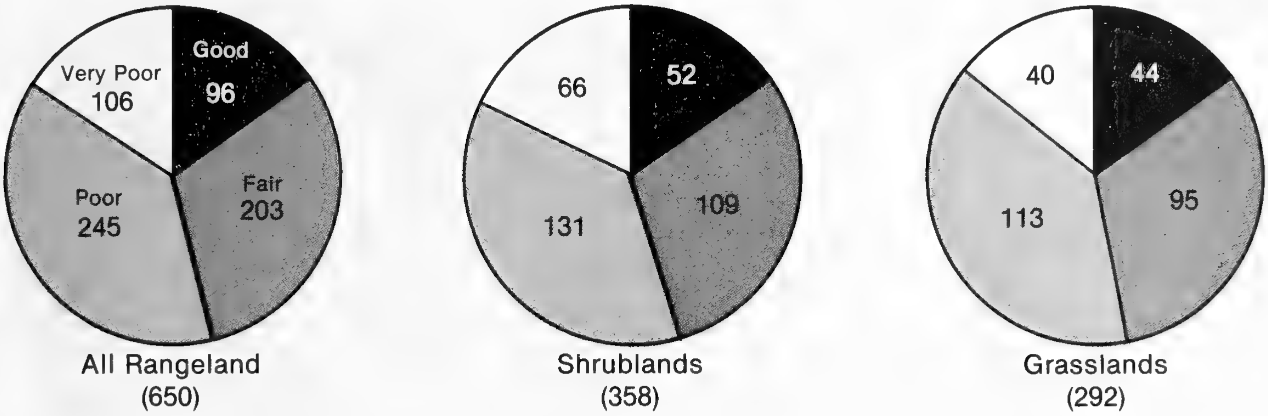
The Great Plains ecosystems, Texas savanna, plains grasslands, and prairie, are in generally higher condition than the arid and semiarid ecosystems of the Southwest. The generally better growing conditions in these ecosystems have contributed to their present relatively high condition ratings.

Most of the arid and semiarid ecosystems of the Southwest are in generally poorer condition than the other rangeland ecosystems, reflecting their long history of unmanaged grazing and the tough growing conditions. The high condition of the desert shrub ecosystem, 54 percent being in fair and good condition, may therefore be surprising. However, many areas in this ecosystem are grazed only in the winter, while other areas in the ecosystem are ungrazed because of lack of drinking water for livestock.

Figure 5.4

Condition of Shrublands and Grasslands in the Contiguous States, 1976

Mil. Acres



Effect of condition on forage supply. — Each ecosystem has its inherent natural potential productivity or ability to produce herbage and browse. The natural potential production is the average annual production that could be expected from an ecosystem without irrigation or fertilization if that ecosystem were in good condition. Thus the two largest rangeland ecosystems, plains grasslands and sagebrush, containing 175 and 130 million acres respectively, each have a potential to produce an average of a little over one-half ton per acre annually. Wet grasslands have the highest potential, over 5,100 pounds; and the desert shrub the lowest, about 250 pounds (table 2.6). Natural potential of deserts for forage is virtually nil.

Since rangeland in fair, poor, or very poor condition produces less than its natural potential, any improvement in range condition can usually be expected to increase the supply of forage produced. Conversely, any downward departure from good condition will usually have a negative effect upon the supply. Thus, the actual production of rangelands is a function of present condition and the inherent production of the ecosystem.

Figure 5.5 shows the present production of the rangelands in the contiguous States. The rangelands having the highest production of herbage and browse are the grasslands in the Central Plains and in the coastal and near coastal Southern and Pacific Southwest areas. The sagebrush lands of the Intermountain and Pacific Northwest also are significant contributors of herbage and browse. Although areas to the east of the Great Plains have the water and soil requirements for high forage growth, plant succession has resulted in their being covered with forests rather than with rangeland plant communities. In the Pacific Northwest, the heavily timbered zones are similarly high in timber growth but low in forage output, while the arid lands of the Southwest represent the least productive areas for forage under historical management for reasons noted previously. Should range conditions of higher herbage and browse producing areas be improved, significant increases in forage production can be expected.

Grazing Use Of Range

Use by livestock. — Livestock grazing is the major use of the range. In 1976, almost two-thirds of the 1,207 million acres of forests and rangelands, or 789 million acres, were grazed in the contiguous States. Most of the grazed range is in the 17 traditional range States west of the Mississippi River. Here the forests and rangelands are characterized by large acreages of palatable and nutritious forage plants and have been grazed by livestock ever since settlement by the early pioneers and before that by large wild herbivores. These States have about 70 percent of the forests and rangelands in the 48 States, but they provide some 720 million acres of range grazing, or 91 percent of the range grazed in the 48 States (table 5.3).

The 31 States east of the Mississippi River supply some 69 million acres of grazed range, only 9 percent of the total grazed in the contiguous States. The range grazing in the East reported here relates mostly to livestock grazing in forest lands under varying levels of management. Most livestock grazing in the East

Table 5.2 — *Condition of rangeland ecosystems in the United States, 1976*[1]

(Thousand acres)

Ecosystem	Total	Good	Fair	Poor	Very Poor
Contiguous States:					
Grasslands					
Mountain grasslands	26,871	4,705	9,725	8,392	4,049
Mountain meadows	3,284	1,063	1,275	692	253
Plains grasslands	175,239	25,809	59,874	69,377	20,178
Prairie	41,186	5,740	14,098	15,695	5,654
Desert grasslands	24,744	2,086	6,109	12,483	4,066
Wet grasslands	4,411	748	1,219	911	1,533
Annual grasslands	10,153	1,336	511	3,731	4,576
Alpine	6,775	2,897	1,835	1,948	95
Total	292,663	44,384	94,646	113,229	40,403
Shrublands:					
Sagebrush	129,872	16,012	46,794	45,470	21,495
Desert shrub	81,171	14,130	29,581	25,547	11,913
Shinnery	4,726	780	1,310	1,915	723
Texas savanna	28,429	4,666	6,689	13,037	4,037
Southwestern shrubsteppe	43,213	4,535	6,398	17,923	14,358
Chapparal-mountain shrub[2]	15,477	1,829	3,711	5,870	4,063
Pinyon-juniper[2]	47,305	4,285	13,509	21,012	8,498
Desert	7,490	5,739	865	486	400
Total	357,683	51,976	108,857	131,360	65,488
Total, Contiguous States	650,346	96,361	203,503	244,588	105,891
Alaska:[2]					
Muskeg-bog	14,383	14,383	0	0	0
Shrub thickets	17,762	14,853	2,023	886	0
Moist tundra	66,576	40,344	22,902	3,330	0
Wet tundra	26,256	26,256	0	0	0
Alpine tundra	103,114	85,069	18,045	0	0
Aleutian moist tundra	1,215	850	365	0	0
Aleutian alpine	2,165	1,517	541	107	0
Total	231,471	183,272	43,876	4,323	0
Hawaii:					
Forest-shrub-grass mosaic	493	72	72	95	254
Koa-mamani-parkland	250	117	58	73	2
Grass-shrub-barren mosaic	225	154	36	30	5
Total	968	343	166	198	261
Total, United States	882,784	279,975	247,545	249,109	106,152

[1]For definition of condition class, see text.
[2]Considered as other forest in the Forest and Range Land chapter.
Note: Totals may not add due to rounding.

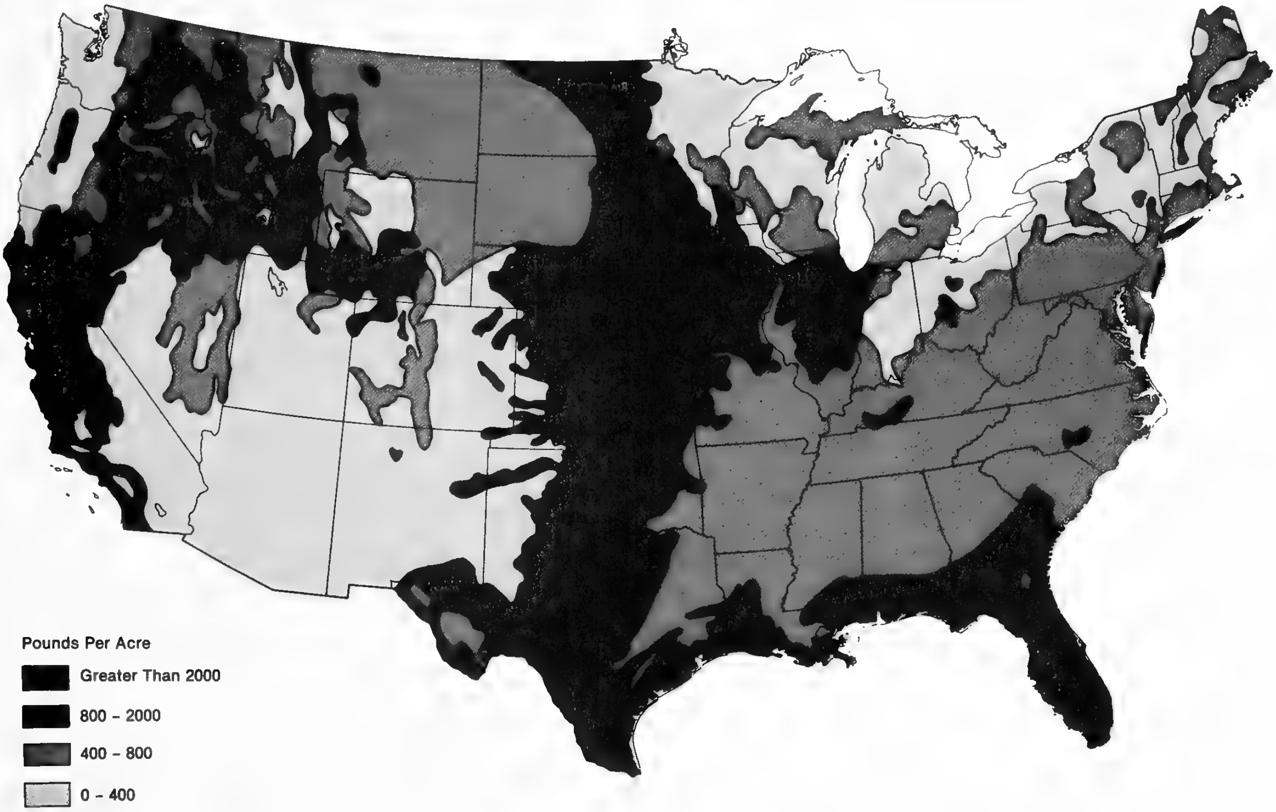
is now, and has been for many decades, confined primarily to lands cleared of forests and then seeded to domesticated grasses and forbs. These cleared lands are considered as improved pastures and are not included in the Nation's range base.

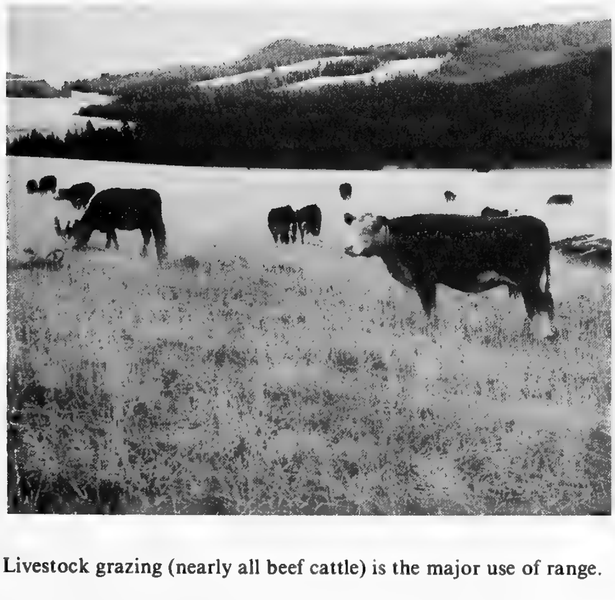
Only a small portion of Alaska is currently grazed by livestock. There are cattle and sheep on some of the Aleutian Islands; cattle on Kodiak Island; reindeer on Umnak, Atka, and Nunivak Island, and on the Seward Peninsula; and musk ox on Nunivak Island. In the past, cattle grazed small isolated areas in the mountains and the reindeer herds roamed over most of the North Slope and western tundra areas. Their numbers and area grazed have declined steadily in recent decades.

While livestock grazing occurs on some large ranches using range in Hawaii, there is little range grazing in the remaining Pacific Islands, Puerto Rico, and the Virgin Islands. Grazing in these islands is important locally, but it represents a very tiny fraction of the Nation's grazing use.

Figure 5.5

Herbage and Browse Production in the Contiguous United States, Under Prevailing Vegetation Cover and Range Condition, 1976





Livestock grazing (nearly all beef cattle) is the major use of range.

Most of the range grazing occurs on non-Federal lands. In 1976, 531 million acres of non-Federal range were grazed — two-thirds of all the range grazed by livestock (table 5.4). The predominance of non-Federal grazed lands is especially evident in the eastern sections where more than 99 percent of the area grazed in the North and 91 percent in the South are in non-Federal ownership. More importantly, non-Federal landowners own 98 percent of the range grazed in the six Great Plains States. This accounts for 25 percent of all the range grazed in the contiguous States.

Some 258 million acres of Federally owned range were grazed in 1976. Almost 98 percent of the grazed Federal lands are in the 17 western States and only 2 percent, or 4.7 million acres, are in the 31 States east of the Mississippi River. Only in the Pacific Northwest section do Federal lands supply more than half of the grazed range. About 57 percent of the grazed lands in Federal ownership are administered

Table 5.3—*Forest and rangeland grazed in the 48 contiguous States, 1976*
(Thousand acres)

Section, region, and State	Total	Forest	Rangeland
North			
Northeast			
Connecticut	20	20	0
Delaware	5	5	0
Maine	77	77	0
Maryland	139	139	0
Massachusetts	34	34	0
New Hampshire	30	30	0
New Jersey	0	0	0
New York	719	719	0
Pennsylvania	561	561	0
Rhode Island	0	0	0
Vermont	390	390	0
West Virginia	1,754	1,754	0
Total	3,729	3,729	0
North Central			
Illinois	1,199	1,199	0
Indiana	743	743	0
Iowa	1,521	1,514	7
Michigan	210	210	0
Minnesota	1,598	1,533	65
Missouri	5,041	3,998	1,043
Ohio	1,470	1,470	0
Wisconsin	563	563	0
Total	12,345	11,230	1,115
Total, North	16,074	14,959	1,115
South			
Southeast			
Florida	9,173	6,703	2,470
Georgia	4,577	4,577	0
North Carolina	833	833	0
South Caroina	460	460	0
Virginia	5,498	5,498	0
Total	20,541	18,061	2,480
South Central			
Alabama	3,817	3,814	3
Arkansas	8,328	7,563	657
Kentucky	1,312	1,312	0
Louisiana	9,311	8,794	517
Mississippi	7,448	7,439	9
Tennessee	2,412	2,248	164
Total	32,538	31,170	1,368
Total, South	53,079	49,231	3,848
Rocky Mountains and Great Plains	105	121	137
Rocky Mountains			
Arizona	61,877	4,157	57,720
Colorado	47,541	11,678	35,863
Idaho	34,448	11,653	22,795
Montana	62,484	10,031	52,453
Nevada	57,406	499	56,907
New Mexico	61,804	2,923	58,881
Utah	40,092	4,238	35,854
Wyoming	52,107	6,089	46,018
Total	417,759	51,628	366,491
Great Plains			
Kansas	17,129	1,318	15,811
Nebraska	24,265	619	23,646
North Dakota	12,491	252	12,239
Oklahoma	17,062	8,419	8,643
South Dakota	24,480	1,519	22,961
Texas	105,618	14,299	91,319
Total	201,045	26,426	174,619
Total, Rocky Mountains and Great Plains	618,804	77,694	541,110
Pacific Coast			
Pacific Northwest			
Oregon	36,590	13,221	23,369
Washington	11,939	5,672	6,267
Total	48,529	18,893	29,636
Pacific Southwest			
California	52,486	12,989	39,497
Total	52,486	12,939	39,497
Total, Pacific Coast	101,015	31,882	69,133
Total, Contiguous States	788,972	173,766	615,206

Note: Totals may not add because of rounding

Table 5.4—*Forest and rangeland grazed in the 48 contiguous States by ownership and by section, and region, 1976*

(Thousand acres)

Section and region	Total grazed			Forest Service			Bureau of Land Mgmt.			Other Federal			Non-Federal		
	Total	Forest	Range-land	Total	Forest	Range-land	Total	Forest	Range-land	Total	Forest	Range-land	Total	Forest	Range-land
North															
Northeast	3,729	3,729	0	17	17	0	0	0	0	1	1	0	3,711	3,711	0
North Central	12,345	11,230	1,115	73	8	65	0	0	0	24	23	1	12,248	11,199	1,049
Total, North	16,074	14,959	1,115	90	25	65	0	0	0	25	24	1	15,959	14,910	1,049
South															
Southeast	20,541	18,061	2,480	1,073	1,073	0	0	0	0	0	0	0	19,468	16,988	2,480
South Central	32,538	31,170	1,368	3,482	3,482	0	0	0	0	32	32	0	29,024	27,656	1,368
Total South	53,079	49,231	3,848	4,555	4,555	0	0	0	0	32	32	0	48,492	44,644	3,848
Rocky Mountains and Great Plains															
Rocky Mountains	417,759	51,268	366,491	68,827	34,594	34,233	125,926	1,696	124,230	8,269	306	7,963	214,737	14,672	200,065
Great Plains	201,045	26,426	174,619	5,086	1,828	3,258	357	44	313	35	9	26	195,567	24,545	171,022
Total, Rocky Mountains and Great Plains	618,804	77,694	541,110	73,913	36,422	37,491	126,284	1,740	124,543	8,304	315	7,989	410,304	39,217	371,087
Pacific Coast															
Pacific Northwest	48,529	18,893	29,636	11,866	10,141	1,725	13,553	506	13,047	5	3	2	23,105	8,243	14,862
Pacific Southwest	52,486	12,989	39,497	11,401	6,541	4,860	7,695	1	7,694	146	105	41	33,244	6,342	26,902
Total, Pacific Coast	101,015	31,882	69,133	23,267	16,682	6,585	21,248	507	20,741	151	108	43	56,349	14,585	41,764
Total, Contiguous States	788,972	173,766	615,206	101,825	57,684	44,141	147,531	2,247	145,284	8,512	479	8,033	531,104	113,356	417,748

by the Bureau of Land Management, 39 percent by the Forest Service, and the balance by the other Federal agencies.

Use by wild horses and burros. — Wild horses and burros in the western United States date back to the 16th century when some of the mounts and pack animals of the Spanish conquistadors escaped captivity and survived and prospered in the wild. By the 1930's, populations of these feral animals had grown until they were considered as serious problems on many western ranges. In the late 1940's and early 1950's, Federal agencies encouraged the removal of feral horses and burros because they competed for forage needed by other grazing animals and were causing serious resource damage, especially in their winter ranges.

As a result of public concern over the control programs being carried on, Congress passed the Wild Horses and Burros Protection Act of 1971.[13] The Act delegated to the Secretary of the Interior and the Secretary of Agriculture the authority and responsibility for the protection, management, and control of wild free-roaming horses and burros on public lands administered by the Bureau of Land Management and the Forest Service. The Act does not apply to horses and burros roaming yearlong on private lands or on lands administered by other Federal or State agencies.

Prior to passage of this Act, direct management and welfare of wild animals on Federal lands, except those included in international treaties, had been generally considered as the responsibility of the States, while the Federal agencies were responsible for managing the habitat. Now the Bureau of Land Management and the Forest Service have direct responsibilities for the wild horses and burros on lands they administer.

Most of the wild horses and burros are on Federal lands administered by the Bureau of Land Management. Only a small proportion of their population is on land administered by the Forest Service. This is believed to be due to the generally rougher terrain and more severe winters of National Forest System land.[14]

Wild horse populations on lands administered by the Bureau of Land Management and Forest Service have increased dramatically since passage of the Act, while burro populations are believed to be stable or perhaps declining (table 5.5). The 1971 estimates for both kinds of animals are rather crude and considered as unreliable, especially for wild horses. The 1974 burro estimate is also considered unreliable because of highly inflated estimates made in Arizona prior to an aerial census.

Table 5.5 — *Estimates of wild horses and burros in 10 western States in 1971, 1974, and 1976*

Animal	1971[1]	1974	1976
Horses	17,300	45,207	56,335
Burros	8,045	14,646[2]	7,101
Total	25,345	59,853	63,436

[1] 1971 estimates are for Federal lands administered by Bureau of Land Management only. Other years include lands administered by Forest Service as well as the Bureau of Land Management.

[2] Estimate made prior to aerial census in 1975 and not considered reliable.

Source: U.S. Department of the Interior, Bureau of Land Management, and U.S. Department of Agriculture, Forest Service. *Second report to Congress: Administration of the Wild Free-Roaming Horse and Burro Act (sic) 1976.* Washington, D.C. 45 p., with appendix. 1976.

U.S. Department of the Interior, Bureau of Land Management, and U.S. Department of Agriculture, Forest Service. *1978 report to Congress: Management of wild free-roaming horses and burros on the Public Lands and lands of the National Forest System.* (In draft)

Passage of the Wild Horses and Burros Protection Act of 1971 has resulted in dramatic increases in wild horse populations on Federal lands. Concerns are mounting about the impacts of the horses on vegetation and soil resources and other grazing animals.

[13] 92nd U.S. Congress. Wild Horses and Burros Protection Act. Public law 92-195. 1971.

[14] U.S. Department of the Interior, Bureau of Land Management, and U.S. Department of Agriculture, Forest Service. Second report to Congress: Administration of the Wild Free-Roaming Horse and Burro Act (sic). 1976. Washington, D.C. 45 p., with appendix. 1976.

The increasing horse numbers, 25 percent increase in the 1974-1976 period, are resulting in heavy range use in some places. Concerns are mounting about the impacts of these animals upon vegetation and soils resources and their competition with other grazing animals, both domestic and wild. The Public Rangelands Improvement Act of 1978[15] may offer some relief because it provides improved measures for the two agencies to dispose of surplus animals, i.e., animals in excess of the sustained grazing capacity of the range.

Use by wildlife. — In addition to providing forage for livestock and wild horses and burros, the Nation's range, as stated previously, also furnishes food and cover for millions of wild animals. No reliable national population data are available for most wildlife species, or even such common big game animals as deer and elk. However, Wagner[16] has summarized recent population estimates by the fish and game departments of the western States (table 5.6).

These estimates, even though incomplete, indicate big game populations in excess of 4 million animals for the 11 western States. Present numbers, except for deer, are far lower than for the populations believed to have been in the area when Columbus landed in the New World. Wagner speculates that the pre-Columbus populations were: bison, 5-10 million; pronghorn 10-15 million; bighorn sheep, 1-2 million; mule deer and blacktail deer; 5 million; and elk, 2 million.

An estimated 11 million animal unit months (AUM's) of forage are required to sustain Wagner's present populations.[17] Data developed for this report indicate that as much as 154 million AUM's of herbage and browse are currently available for wild ruminants (e.g. deer, elk, moose, etc.) in the 11 western States. This is far more than that required to meet the forage requirements of the populations listed by Wagner.

Wildlife use of the Nation's forests and rangelands is discussed in further detail in the wildlife chapter of this report.

Nongrazing Uses

While the common product from range is forage for livestock, big game, and other herbivores, the range does yield many other products. Rangelands are important sources of coal, oil, uranium, and other economically significant minerals. They provide sites for many forms of outdoor recreation such as hunting, hiking, off-road vehicle use, birdwatching, flower viewing, and rock hounding to name a few. They also serve other purposes described below.

Commercial plants. — Some old and well-established range uses are assuming far greater importance now than they did in the past. For example, the harvesting of pinyon nuts was once largely the activity of some Indian tribes of the Southwest. Now it is also a popular recreational activity for many people. Juniper has traditionally provided fenceposts and, along with pinyon, firewood for ranchers. Now with escalating costs of fuel oil and natural gas, urban dwellers are also demanding juniper and pinyon for use as fuel. The demands are so great in some areas that supplies must be closely managed.

In 1910, about half of all United States rubber came from guayule, a range shrub of arid lands in Texas and Mexico. The wild guayule stands were soon depleted and the hevea rubber tree of the East Indies became the source of natural rubber. But in World War II, when the United States lost more than 90 percent of its rubber supplies, attention focused once again upon guayule as a source of rubber. Three million pounds of rubber for the war effort were produced from the shrub. After the war, the Nation returned to the hevea rubber tree and to petroleum as its sources of rubber.[18] Recent research, however, shows that rubber production in young guayule plants can be increased from two to six times by spraying with mixtures of chemicals called bioregulators. Should these developments prove to be commercially feasible, some 5 million acres of arid rangeland in New Mexico, Arizona, California, and Texas may be involved in the production of guayule rubber.[19]

Other research has led to pilot-scale production of petroleum from range plants of the genus *Euphorbia*.[20] As much as 25 million acres of dry rangelands could be managed as "hydrocarbon plantations," if the pilot tests prove to be economically successful.[21]

[15] 95th U.S. Congress. Public Rangelands Improvement Act. Public Law 95-514. 1978.

[16] Wagner, Frederic H. Livestock grazing and the livestock industry. Chapter 9, p. 121-149, in Wildlife and America: Contributions to an understanding of American wildlife and its conservation, H. P. Brokaw, editor, Council on Environmental Quality. 1978.

[17] An animal unit month (AUM) is the amount of forage required by a 1,000-pound cow or its equivalent in 1 month.

[18] National Academy of Science. Guayule: an alternative source of natural rubber. 80 p. 1977.

[19] Dean, J. Paul. New method increases rubber from guayule. Agr. Res. 27(2): 810, illus. 1978.

[20] Calvin, M. Energy and materials via photosynthesis. P. 231-259 in R. Buvet and M. J. Allen, eds. Living systems as energy converters. North Holland Publishing Co., New York. 1977.

[21] Pimental, David, Donald Nafus, Walter Vergara, Dan Papaj, Linda Jaconetta, Marty Wulfe, Linda Olsvig, Kerry French, Mark Loye, and Ellen Medoza. Biological solar energy conversion and U.S. energy policy. Bioscience 28(6): 376-382. 1978.

Table 5.6 — *Current estimates of big game populations in the western States*

State	Bison	Pronghorn	Bighorn	Mule and blacktail deer	Elk	Total
Arizona	320	7,000	2,000	130,000	10,000	149,320
California	—	4,869	3,750	650,000	3,392	662,011
Colorado	—	32,000	2,500	325,000	120,000	479,500
Idaho	25	13,250	2,975	178,000	50,600	244,850
Montana	No est.	No est.	No est.	No est.	No est.	—
Nevada	—	5,000	4,000	81,700	200	90,900
New Mexico	—	26,900	800	261,600	27,500	316,800
Oregon	—	11,000	400	1,050,000	107,000	1,168,400
Utah	150	2,500	450	275,000	13,000	291,100
Washington	—	50	435	373,500	60,000	433,985
Wyoming	—	168,000	3,100	280,000	63,000	514,000
Total	495	270,569	20,410	3,604,800	454,692	4,350,966
Percentage of Pre-Columbus population	*	2-3	*	100**	25	15-20

Source: State fish and game departments as reported by Wagner, Frederic H. *Livestock grazing and the livestock industry*. Chapter 9, p. 121-149. In *Wildlife and America: Contributions to an understanding of American wildlife and its conservation*. H. P. Brokaw, editor, Council on Environmental Quality, 1978.

*Trace
**Approx.

Some range types, such as the pinyon-juniper forests, provide products such as fence posts, firewood and nuts, in addition to forage.

Another shrub of the Southwest, jojoba, is used as a commercial source of wax. More recently, research has shown that jojoba wax can substitute for whale oil, a finding of great importance since many whales are classified as endangered and are protected under terms of the Endangered Species Act of 1973.[22] Numerous range plants contain medicinal properties; one, false hellebore, contains an alkaloid used as a heart and arterial sedative.

These recent developments could lead to conflicting demands for rangeland areas in the future. Sound planning must ensure that these uses will be compatible with the many other uses of rangelands.

Endangered and threatened plants. — The Endangered Species Act of 1973 is the strongest legislation yet enacted by Congress to protect endangered and threatened animals and plants. As required by the Act, the Smithsonian Institution reviewed the status of plant species in the United States and reported to the Secretary of the Interior that 3,187 species, subspecies, and varieties needed protection.[23] The Secretary reduced the list of plants and in June 1976 proposed that 1,783 plants be classified. By July 1, 1979, only 19 of 1,783 proposed plants had been officially classified by the Secretary as threatened or endangered and are under protection of Federal law (table 5.7).

Under the Endangered Species Act, Federal agencies must ensure that actions they authorize, fund, or carry out will not jeopardize the existence of those species. Potentially, this may pose problems regarding management of some rangelands. At this time, however, conflicts between well-managed grazing and endangered or threatened plants are considered to be minor. None of the classified species has been so categorized because of livestock grazing. However, should any classified plants be jeopardized by grazing, adequate steps must be taken to protect them.

Management of the Range

Management of the range varies greatly in the United States. Climate, weather, topography, productivity of the ecosystem, markets, goals, and financial positions of the operator — even tradition — all bear importantly on the choice of operation and level of management practiced. The complex interrelationships and interactions among these factors provide an almost infinite number of management situations.

Management levels defined. — To facilitate discussions, the vast array of management situations has been classified into five broad management levels:

Land management without livestock (no livestock). Livestock grazing is eliminated (except for use by recreational pack and saddle stock), but the range is protected from such natural catastrophes as wildfire and insect epidemics. Any previous damage to the resource is corrected to maintain a stewardship level of management. Examples of areas managed at this level are most national and State parks, many wildlife refuges and wildernesses, and many research natural areas.

Land management with some livestock (some livestock). Goal is to control livestock numbers within present capacity of the range, but little or no attempt is made to achieve uniform distribution of livestock. Range management investments are minimal and only to the extent needed to maintain stewardship of the range in the presence of grazing. Past resource damage is corrected and resources are protected from natural catastrophes.

Extensive management of the range and livestock (extensive management). Goal is to maintain full plant vigor and to achieve full livestock utilization of available forage. Goal is achieved through implementation of improved grazing systems and construction and installation of range improvements. Cultural practices, such as seeding and fertilizing to improve forage quality and quantity, are not used.

Intensive management of range and livestock (intensive management). Goal is to maximize production and utilization of livestock forage consistent with maintaining the range and its environment and to provide for the multiple use of the range. All available technology and practices are considered and used as they may be cost-efficient to improve livestock production, quality, and utilization.

Land management with livestock production maximized (maximize livestock). Goal is to maximize production of livestock while maintaining the soil and water resources. Existing vegetation may be replaced with better forage species. This level requires large investments for construction and implementation of improvements, cultural practices, and animal husbandry, but all practices used must be cost-efficient. Multiple use of the resources is not a constraint. This management level generally does not meet the legal management requirements for most Federal lands.

Maintenance of the soils and water resources is required in all five management levels, but multiple-use requirements apply only in some livestock, intensive management, and extensive management levels.

[22] 93rd U.S. Congress. The Endangered Species Act of 1973. Public Law 93-204. 1973.

[23] Smithsonian Institution. Report on endangered and threatened species of the United States. 200 p. 1974.

Table 5.7 — *Plants classified as endangered or threatened in the United States by date, classification, State and land ownership, as of July 1, 1979*

Technical name	Common name	Classification	State	Land Ownership
Classified Aug. 11, 1977:				
Castilleja grisea	San Clemente Island Indian paintbrush	Endangered	California	Other Federal
Delphinum kinkiense	San Clemente Island larkspur	Endangered	California	Other Federal
Lotus scoparius	San Clemente broom	Endangered	California	Other Federal
Melicothamnus clementinus	San Clemente Island bush mallow	Endangered	California	Other Federal
Classified April 4, 1978:				
Aconitum novoboracense	Northern wild monkshood	Threatened	Iowa, New York, Ohio, Wisconsin	Non-Federal
Astragalus perianus	Rydberg milkvetch	Threatened	Utah	Forest Service
Baptisia arachnifera	Hairy rattleweed	Endangered	Georgia	Non-Federal
Betula uber	Virginia roundleaf birch	Endangered	Virginia	Forest Service Non-Federal
Dudleya traskiae	Santa Barbara Island liveforever	Endangered	California	Other Federal
Erysimum capitatum var. *angustatum*	Contra Costa wallflower	Endangered	California	Non-Federal
Oenothera avita ssp. *eurekensis*	Eureka evening primrose	Endangered	California	Bureau of Land Mgmt.
Oenothera deltoides ssp. *howellii*	Antioch Dunes evening primrose	Endangered	California	Non-Federal
Pedicularis furbishiae	Furbish lousewort	Endangered	Maine	Non-Federal
Swallenia alexandrae	Eureka dune grass	Endangered	California	Bureau of Land Mgmt.
Trillium persistens	Persistent trillium	Endangered	Georgia, South Carolina	Forest Service Non-Federal
Vicia menziesii	Hawaiian wild broadbean	Endangered	Hawaii	Non-Federal
Zizania texana	Texas wild-rice	Endangered	Texas	Non-Federal
Classified April 24, 1979				
Rhododendron chapmannii	Chapman rhododendron	Endangered	Florida	Non-Federal Other Federal
Classified June 6, 1979:				
Echinaceae tennesseensis	Tennessee purple coneflower	Endangered	Tennessee	Non-Federal

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Endangered Species.

In addition to these five management levels, another situation — exploitative grazing, i.e., grazing with no concern for multiple use or the maintenance of basic soil and water resources — is, unfortunately, much too common. Though such grazing is practiced, it is not desirable management because the sacrifice of soil and water resources to obtain short-term monetary gains is too detrimental to the Nation's welfare in the long run. In addition to being used as a general level of management, this kind of grazing also occurs in local spots or areas on ranges that overall are being managed under any of the other five management levels.

Production by management level. — To be truly cost-efficient, higher management levels should be employed where productive potentials are the greatest, and lower levels of management should be used on ecosystems with lower potentials. At present, this is only partly the case. For example, only about 40 percent of the production from perennial grassland ecosystems comes from lands managed in the two highest management categories — intensive management and maximization of livestock (table 5.8). In the annual grasslands, a somewhat different situation exists in that 52 percent of the grazing production comes from extensive management — a relatively low management level. Shrublands are managed less intensively than the grasslands, with 36 percent of the output coming from the two highest management levels. Unfortunately, exploitative grazing occurs at far too great an extent regardless of the productive potential of the ecosystems.

Large differences in the quality and quantity of forage occur among the ecosystem groups. Grazing potential varies accordingly. In 1976, the forest and rangeland ecosystems produced 212 million animal unit months (AUM's) of grazing (table 5.8). The grassland ecosystems accounted for 64 percent of the total AUM's produced. Shrublands contributed 25 percent, and despite their large area, the eastern forests made up only 8 percent, and the western forests only 2 percent of the total. Although the western forests provide only a small proportion of the total grazing, they are producing over 5 million AUM's and their importance as a resource should not be discounted.

About three-fourths of all the AUM's come from five range ecosystems and each of them produced more than 10 million AUM's of grazing in 1976. The plains grassland, with 54.3 million AUM's, produced the most, followed by the prairie (45.4 million), sagebrush (24.6 million), mountain grassland (16.6 million), and Texas savanna (16.5 million). All of these are relatively high producing ecosystems (table 2.6) and all have substantial areas that could be improved in condition (table 5.2); therefore, all could be expected to produce substantially more AUM's of grazing if management levels were intensified and range conditions improved, and if economic and ownership circumstances permitted it.

Stewardship management. — Description of management strategies would be seriously incomplete without mention of the range stewardship concept. Stewardship is simply exercising sufficient care of the land so that it is passed on to succeeding generations in as good or better condition as it was received. Thus stewardship assures future availability of a productive range resource. Future generations will then have options as to the uses to be made of the range, whether it be used for grazing, wildlife habitat, water, air, open space, or recreation. The stewardship concept is essential to ensure progress in restoring and maintaining the productivity of rangelands. While meat production is a primary factor in the demand for range, as will later be discussed, stewardship of soil and vegetation resources is a matter of vital public interest, and is an important element in discussions about supplying future demands for meat.

One index of the effectiveness of land stewardship is the rate of soil loss from the Nation's lands. Pimentel, et al[24] estimated that the United States has lost one-third of its original topsoil in only 200 years, and that the rate of loss on agricultural lands is increasing rather than decreasing. More recent estimates[25] indicate that about 77 percent of the agricultural lands in now Federal ownership have soil losses due to sheet and rill erosion of less than 5 tons per acre per year, a loss generally considered as acceptable on average croplands. These estimates also indicate that over 80 percent of the non-Federal rangelands and forests have soil losses averaging less than 2 tons per acre per year. No comparable estimates are available for Federal forests and rangelands, but preliminary data collected for this assessment suggest that the bulk of the Federal forests and rangelands have erosion rates that are no higher than those for non-Federal lands.

Factors Affecting Demand for Range Grazing

The demand for range grazing is derived from consumers' demands for livestock products. These livestock products are meat, hides, wool, tallow, insulin,

[24] Pimentel, D.; E. Terhune; R. Dyson-Hudson; S. Rochereau; R. Samis; E. Smith; D. Denman; D. Reifschneider; and M. Shepard. Land degradation: Effect on food and energy resources. Science 194: 149. 1976.

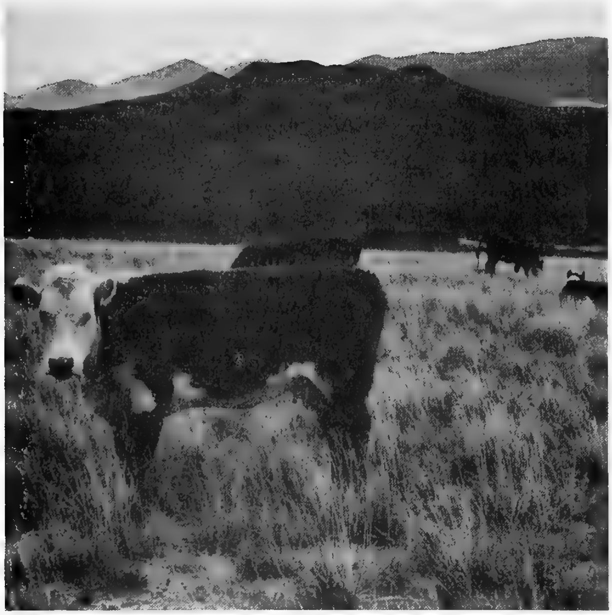
[25] U.S. Department of Agriculture. Soil and Water Resources Conservation Act: Appraisal 1980, review draft, part 1. 1979.

Table 5.8 — *Production of range grazing in the 48 contiguous States ecosystem group, by ecosystem, and management level, 1976*

(Thousand animal unit months)

Ecosystem group and ecosystem	Total	Some livestock	Management level			
			Extensive management	Intensive management	Livestock maximized	Exploitative grazing
Grasslands						
Mountain grasslands	16,597	894	6,324	3,230	4,971	1,177
Mountain meadows	822	406	383	25	8	0
Plains grasslands	54,325	3,110	24,852	9,854	7,331	9,178
Prairie	45,350	925	15,104	7,523	15,558	6,241
Desert grasslands	2,998	90	446	91	113	2,258
Annual grasslands	10,649	139	5,402	5,030	0	78
Wet grasslands	5,425	225	734	1,168	1,645	1,652
Alpine	216	193	23	0	0	0
Total, Grasslands	136,382	5,982	53,268	26,921	29,626	20,584
Shrublands						
Sagebrush	24,641	2,446	8,571	2,610	2,950	8,064
Desert shrub	2,809	369	1,645	0	0	795
Southwestern shrubsteppe	3,775	18	184	2,793	0	781
Shinnery	1,848	117	536	643	511	42
Texas savanna	16,493	434	1,337	6,830	1,094	6,799
Chaparral-mountain shrub	1,612	337	73	430	743	29
Pinyon-juniper	2,393	994	439	647	137	176
Desert	0	0	0	0	0	0
Total, Shrublands	53,571	4,715	12,785	13,953	5,435	16,686
Western Forests						
Douglas-fir	1,000	827	113	53	0	6
Ponderosa pine	1,617	431	508	102	291	285
Western white pine	50	8	5	*	37	0
Fir-spruce	418	190	224	2	0	2
Hemlock-Sitka spruce	173	21	18	*	134	0
Larch	178	39	26	3	109	1
Lodgepole pine	527	352	175	0	0	*
Redwood	28	16	12	0	0	0
Hardwood	1,222	178	431	487	116	10
Total, Western Forests	5,213	2,062	1,512	647	687	304
Eastern Forests						
White-red-jack pine	32	8	22	1	0	[1]
Spruce-fir	15	[1]	2	[1]	12	0
Longleaf-slash pine	3,152	2,010	1,064	0	0	78
Loblolly-shortleaf pine	203	171	16	15	0	1
Oak-pine	1,567	1,039	466	16	0	46
Oak-hickory	7,946	1,547	2,526	2,197	408	1,269
Oak-gum-cypress	1,989	3	21	0	1,964	1
Elm-oak-cottonwood	748	107	480	1	0	160
Maple-beech-birch	961	80	69	800	0	13
Aspen-birch	206	22	5	175	*	3
Total, Eastern Forests	16,820	4,987	4,671	3,205	2,384	1,571
Total, Contiguous States	211,986	17,746	72,236	44,726	38,132	39,145

[1] Less than 1,000 AUM's.



Grasslands provide nearly two-thirds of the animal unit months of grazing on forest and range lands.

and a long list of other byproducts. The demand for grazing for dairy cattle has influenced the demand for range grazing in the past, but dairy will not be a significant claimant of range use in the future. Range grazing by sheep to meet the demand for lamb, mutton, and wool will have some minor influence on future demand for range grazing, but historical data show the decline in the volume of these products in the United States. Each of these livestock products is important, but the magnitude of individual and collective demands for other products is very low as compared to the demand for meat.

Thus, the main factors affecting demand for range grazing are: (1) The demand for meat, (2) the change in relative prices of feed elements, and (3) the change in technology — possible feed substitutions or feed mixtures for producing a given number of livestock efficiently.

Production of beef in the United States typically involves rearing the young animals on pasture and range and finishing them by feeding large amounts of grain. The feed for maintenance of cow herd and calf production depends primarily on grazed and harvested roughages. Grazing (range and non-range) now supplies about 64 percent of the feed consumed by all beef cattle and 79 percent of the feed consumed by sheep in the United States. Therefore, grazing is critical to the continuation of the current system of beef and lamb production.

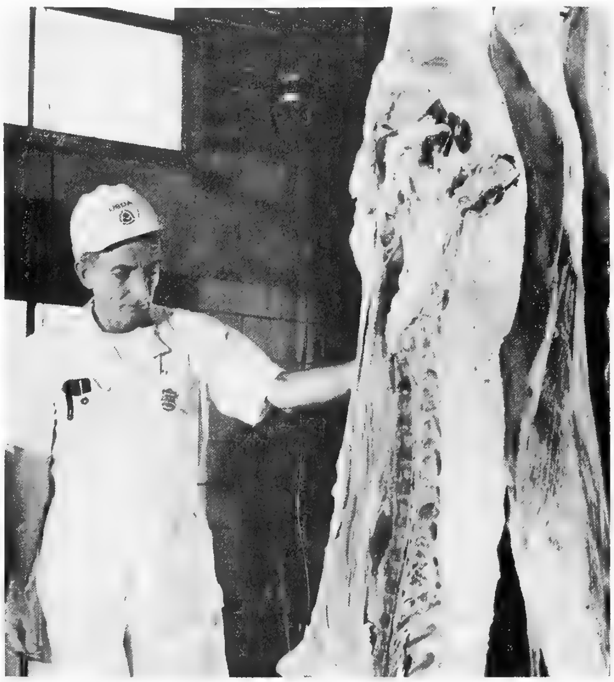
Range grazing is an important part of the economy for many localities and regions, particularly in the West. Maintenance and enhancement of pasture and range have the potential to stabilize or strengthen local rural economies and to improve the economic welfare of rural families.

Demand for Meat

Foremost among the factors influencing future demands for range grazing are the demand for beef and veal per capita and the size of the U.S. population. While demand for many other types of meat or dairy products, i.e., lamb, pork, poultry, milk, etc., also affects the demand for range grazing, the demand for beef by far overshadows the demand for other types of meat. Even though all types of meat are mentioned throughout the analysis, the primary emphasis is on consumption and production of beef.

Per capita meat consumption is a function of many variables, such as disposable income, availability of meat substitutes, consumer preference for different types of meat, and meat grading systems. Changes in any factor will change per capita meat consumption and the demand for range grazing.

Per capita disposable income. — As disposable income increases, a smaller percentage of the income is needed for basic necessities and more of the income is available for increased purchases of meat.



Consumer demand for red meat is the principal factor influencing the demand for range grazing.

Substitutes for meat. — Historically, rising per capita incomes have led to increased per capita consumption of beef and fresh fruits and decreased consumption of foods such as milk, eggs, potatoes, and grain products.[26] This in turn has led to an increase in demand for grazing and harvested roughages.

The only major permanent penetration of the animal protein market by plant protein in the United States has been by soybean products. Soybeans have been used both as meat extenders in processed meats and as meat substitutes. Per capita consumption of soybean products is not expected to increase unless it is assumed that preferences of consumers change. Evidence supporting such a change in preference is not available. Therefore, soybean-derived meat substitutes are expected to have only a negligible effect on the demand for meat. Furthermore, when energy requirements for production of soybean meat analogs are compared to those for beef production, and when other land uses and animal byproducts are considered, beef may be more favorable than formerly thought.[27]

Meat grading and consumer preferences. — Prior to 1975, standards for grading beef as "choice" or "prime" favored grain in cattle rations over grazing and other roughages because extensive feeding of grain was necessary for beef to grade "choice" or better and thus command top market prices. In 1975, meat grading standards were changed so that a smaller portion of grain was needed in cattle rations for beef to be graded "USDA choice."[28] Further changes in grading standards favoring a decreased use of grains and an increased use of roughages are still possible. Current efforts of some other consumer groups are also directed toward decreasing the proportion of grain in the ration, thereby decreasing the amount of fat in beef. However, since consumers have developed a preference for marbled beef produced by using grains as a large part of the total feed ration, the amount and duration of change in consumer preferences are uncertain at this time. Changes in the production process which decrease the quantity of grain fed per animal will increase the amount of roughages needed to produce a given quantity of beef and eventually will cause increases in the demand for grazing.

[26] U.S. Department of Agriculture, Interagency Work Group, *op. cit.*

[27] Yorks, Terence P. Energy use in soybean analog manufacture: a comparison with beef. J. Sci. Food and Agric. (29)895-902. 1978.

[28] U.S. Department of Agriculture, Interagency Work Group, *op cit.*

Relative Prices of Feed Elements

Just as many potential combinations of meat, cereals, and vegetables provide a satisfactory diet for people, there are many combinations of feeds which can be used to produce a given livestock product. Range grazing is one of the several feed elements in the production of livestock. The demand for range grazing is greatly influenced by the relative prices and costs of production of other feed sources, including nonrange grazing.

Feed represents a major portion of total livestock-production costs. Because livestock can be raised effectively on grain or forage or combinations of the two, anything which substantially affects the prices of either will have an impact on the livestock production process. If feed grain prices are relatively low, grain feeding will replace forage in the livestock production process.[29] For example, in the 1950's, grain was relatively inexpensive and it became profitable to feed more grain to livestock, especially beef cattle. Producers placed calves in the feedlot at an earlier age and fed the animals relatively more grain and less forage to reach marketable weight.

Conversely, high grain prices encourage producers to finish animals for slaughter with less feeding of grain. For example, in the early 1970's, high grain prices caused livestock producers to rely more on grazing and other forage.[30] As a result of low prices for slaughter and feeder cattle, producers reduced or liquidated herds, and the beef market became saturated, leading to depressed beef prices which raised the price ratio of grain to beef. Because of the high ratio, roughages increased from 80 percent of total feed consumed by all beef cattle in 1971 to 88 percent in 1974. During the same period, the percent of roughages in the ration of cattle not in feedlots remained stable at 96 percent. Fluctuating grain prices have little effect on rations fed to sheep because pasture and range grazing has always been their principal source of nutrients.[31]

World Agricultural Trade

World demands for food and fiber have the potential to influence the domestic prices of livestock prod-

[29] Council for Agricultural Science and Technology. Multiple use of public lands in 17 western States. Dep. of Agronomy, Iowa State University, Ames, Rep. 45, 36 p. 1975.

[30] Ward, Gerald M. Structure of the United States beef industry as it affects resource use. Unpublished manuscript developed as part of National Science Foundation's Research Applied to National Needs (RANN) Project. "Resource requirements for alternative beef production systems." Washington, D.C. 1976.

[31] Ward, 1976, *op. cit.*

ucts and, therefore, indirectly influence domestic demands for those products and ultimately, range grazing. Although some meat is exported, the United States is a feed grain exporter rather than a meat exporter.

Many nations have greater potential as producers of meat supplies than as markets for United States meat production. They could produce more livestock through increasing their own forage and feed grain production and through increased imports of feed grains. Some nations are protecting their own red meat producers by restricting imports of meat.

The food consumption in several nations has shifted from cereal grains toward animal protein. The result has been a growth in demand for livestock feed grains and oilseeds, and acceleration of world trade in these commodities. The impact of these changes upon the United States livestock industry has been more evident in the feed grain market than directly through meat exports. The effect of increasing United States grain exports may be of greater significance upon the demand for forage than the exportation of meat. However, in projecting the demand for range grazing, agricultural trade is assumed to continue its historical trend in world economic development and trade policies. This includes the policies of trade constraint by countries promoting self-sufficiency. These world trade attributes constitute a moderate growth in demand and will not have a major impact on range grazing in this country.[32]

Livestock-Grazed Roughage Relationships

Grazed roughage consumed by beef cattle increased 19 percent from 1965-67 to 1974-76 (table 5.9). At the same time, producers of dairy cattle reduced their use of grazed roughage by 55 percent, as they moved to increased use of concentrates and a reduced number of dairy cows. Despite an increase in horse and mule populations, use of grazed roughage decreased by 20 percent, or 5 million AUM's, because horse owners shifted to greater use of concentrates and harvested roughage.

Declining sheep and goat populations and reductions in the use of grazed roughage by cattle in feedlots resulted in further reduction of 35 million and 4 million AUM's respectively. Thus, the increase of 150 million AUM's in demand for grazing for beef cattle was almost offset by the 146 million AUM's decline for the other kinds of livestock. Total grazing use, therefore, increased only by 4 million AUM's during that period.[33]

This small increase in grazing use is more apparent than real and should not be used to estimate trends in grazing use during the period 1965-1978. Average use of only two peak periods, 1965-1967 and 1974-1976, were compared to show the changes in grazing use by different kinds of livestock and their effects upon total grazing use. When the annual grazing use data are used to estimate the linear trend, a downward trend of total grazing use becomes apparent for the 1965-1978 period (fig. 5.6).

This downward trend occurred during a period when significant increases occurred in beef production. From 1965 to 1978, beef cattle production was able to increase without increasing total range grazing supplies because a large amount of grazing was released by sheep and dairy cattle and by the substitution of grains for grazing. While the use of grains was caused by need to produce a particular kind of meat, the overall effect on feed supplies was to produce a larger total meat quantity without requiring additional grazing.

Table 5.9 — *Comparison of average total grazing by kinds of livestock, for the contiguous States, 1965-1967 and 1974-1976*

(Million animal unit months-AUM's)[1]

Year	Total	Beef	Feedlot cattle	Dairy	Sheep and goats	Horses and mules
1965-1967	1,063	775	9	187	67	25
1974-1976	1,067	925	5	85	32	20
Change	+4	+150	−4	−102	−35	−5
percent change	*	+19	−44	−55	−52	−20

*Less than 1 percent.

[1] An animal unit month (AUM) is the amount of forage required by a 1,000-pound cow or equivalent in 1 month.

The Projected Demand for Range Grazing

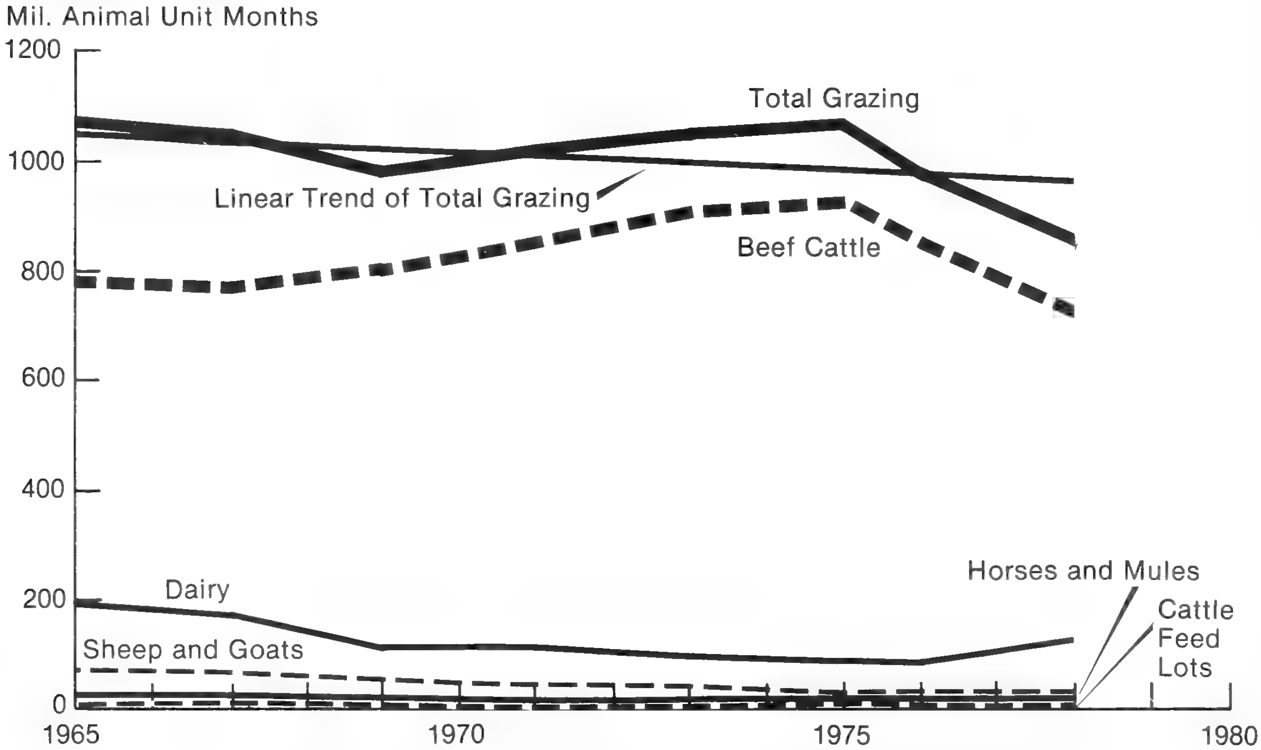
The history of grazing use does not provide sufficient basis for projecting future demand for grazing. The projected demand for range grazing is related to all aspects of national and international agriculture as discussed in the previous section, including changing demands for livestock products and changes in the livestock production process. From this general framework, projections of roughage requirements

[32] Liu, Chun-lan, Gerald Plato, and Allen G. Smith. The demand for grazing roughages in the United States: alternative futures to the year 2030. Unpublished manuscript developed under cooperative agreement between Economics, Statistics, and Cooperatives Service and Forest Service, U.S. Department of Agriculture. 1978, revised 1979.

[33] U.S. Department of Agriculture, Economic Research Service. Livestock-feed relationships: National and State. Sta. Bull. No. 530. 192 p. 1974. Supplement 1974 to Sta. Bull. No. 530. 101 p. 1975. Also unpublished data.

Figure 5.6

Grazing by Kind of Livestock, 1965-1978



and specific indications of demand for range grazing were developed.[34]

[34] The projections and the associated analyses were derived from the National Interregional Agricultural Projections (NIRAP) System, as developed and used by the Economics, Statistics, and Cooperatives Service (ESCS) of the United States Department of Agriculture. Disposable income is assumed to be a function of population and economic activities. Per capita consumptions of beef, veal, and lamb are expressed as a function of per capita disposable income; the trends in consumptions are nonlinear. The magnitudes of income elasticity used in the model for beef and lamb are 0.66 and 1.15 respectively. This income elasticity for beef and veal is adjusted downward as income increases.

For additional discussion of the NIRAP System, see the following:

Allen, George, Greg Gage, Larry Otto, Gerald Plato, and Reuben Weisz. General user's manual for the goal programing algorithm. Working paper for the Commodity Economics Division of the Economic Research Service and the Natural Resource Economics Division of the Economic Research Service (now part of Economics, Statistics, and Cooperatives Service), U.S. Department of Agriculture, August 1977.

Liu, Chun-lan. Statistical analysis of the demand for feed by kind of livestock. Manuscript in review process. 1978.

Liu, Chun-lan, et al., 1978, *op cit.*

Yeh, Chung J. Prices, farm outputs, and income projection under alternative assumed demand and supply conditions. Am. Jour. of Agri. Econ. 58(4): November 1976.

Projected Demand for Meat

Per capita consumption of beef and veal increased from 91 pounds (carcass weight) in 1960 to 133 pounds in 1976 (table 5.10). Consumption of beef and veal is expected to increase to 148 pounds (medium projection level) by 2030. Consumption of lamb and mutton decreased from nearly 5 pounds in 1960 to 2 pounds per capita in 1976. The downward trend is also expected to continue bringing per capita consumption of lamb and mutton to less than 1 pound by 2030.[35] The increasing population and the per capita consumption of beef lead to substantial increases in the projected beef and veal production. On the other hand, the decline in per capita consumption of lamb and mutton is sufficiently great to result in an overall decline in the production of lamb and mutton in spite of the higher population levels (table 5.11).

[35] The decrease in per capita consumption of lamb and mutton is also a result of decline in sheep production due to increased cost related to predator losses, shortage of labor, and other factors.

Table 5.10 — *Historical consumption and projected demand for beef and veal and lamb and mutton in the United States for selected years*
(Pounds per capita)

Historical consumption				
Kinds of meat	1960	1965	1970	1976
Beef and veal	91	105	117	133
Lamb and mutton	5	4	3	2

Projected demand						
Kinds of meat	Projection	1990	2000	2010	2020	2030
Beef and veal	Low	138	142	146	148	153
	Medium	135	140	144	145	148
	High	134	139	141	138	137
Lamb and mutton	Low	2	1	1	*	*
	Medium	2	1	1	*	*
	High	2	1	*	*	*

*Less than 1 pound

Table 5.11 — *Historical and projected production of beef and veal and lamb and mutton in the United States for selected years*
(Million pounds carcass weight)

Historical production				
Kinds of meat	1960	1965	1970	1976
Beef and veal	15,862	19,747	22,273	26,822
Lamb and mutton	768	685	551	371

Projected production						
Kinds of meat	Projection	1990	2000	2010	2020	2030
Beef and veal	Low	30,318	32,360	33,791	34,363	34,882
	Medium	30,714	33,789	36,500	38,432	40,488
	High	31,934	36,426	40,888	44,774	48,949
Lamb and mutton	Low	316	271	228	189	157
	Medium	318	275	234	200	169
	High	333	294	258	227	197

In the high level projection, per capita consumption of beef and veal is lower than in the medium projection. This is because, in this level, the rate of population increase is predicted to be larger than the rate of increase of disposable income. Therefore, per capita disposable income will decrease. As per capita disposable income goes down, per capita consumption of beef will also go down. In addition, the larger population will be competing for beef produced from a limited resource base.

All three projection levels result in significant increases in the total demand for beef. By 2030, the domestic production of beef is projected to increase by 30, 51, and 82 percent for the low, medium, and high projection levels, respectively (table 5.11).

Projected Demand for Livestock Feeds

Projected increase in demands for beef will result in increased demand for all types of livestock feed. If additional beef production is to be achieved, feed supplies must be expanded.

Feed/livestock ratio. — Livestock convert roughages, feed, and cereal grains into protein, vitamins, and other nutrients required and consumed by mankind. This conversion process is measured by the feed/livestock conversion ratio. The ratio compares the total quantity of feeds consumed by all kinds of livestock to the total live weight of those livestock when slaughtered. Thus, the ratio measures all feed, including waste or other losses, that are necessary to deliver a pound of live weight animal. Improvements in such things as animal disease control, nutritional knowledge, improved handling, and storage of feeds all contribute to an improved feed/livestock ratio. The higher the ratio, the more feed is necessary to produce a pound of livestock weight.[36] Management and research efforts are continually underway to lower the feed conversion ratio or to improve feed sources. The feed/livestock ratio for beef animals is expected to decline slowly after 1985. The conversion ratio for dairy cattle and sheep should remain stable or improve. The changing ratios indicate that less total feed will be needed to support a constant number of cattle.[37] Although the feed/livestock ratio for beef is assumed to decrease, the increasing beef cattle populations will offset that trend and increase the importance of grazing.

Cattle cycle. — Cattle prices and production move through a continuous series of cycles, each cycle completed in roughly 10 years (fig. 5.7). These cycles are characterized by high prices when numbers are low, followed by increased livestock numbers, then high production and declining prices, and declining livestock numbers. In the 1978-1979 period, prices are relatively high and the cycle appears to be near the low in cattle numbers. This cyclical pattern is recognized in this demand analysis but the cyclical pattern itself is not projected. Projection data are in terms of 10-year averages around the target year. The cattle cycle also explains the cyclical fluctuations in the consumption of grazing (fig. 5.6).

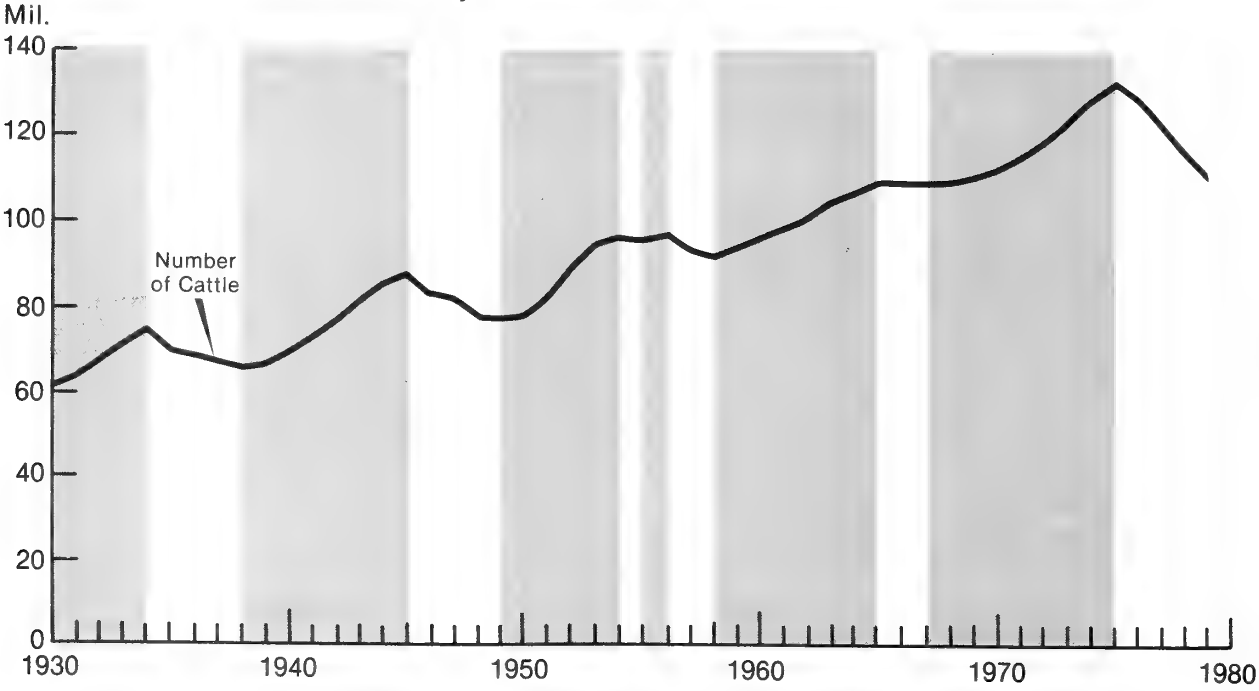
[36] Council for Agricultural Sciences and Technology, 1975, *op. cit.*

[37] Liu, Chun-lan, et. al. 1978, *op. cit.*

Figure 5.7

Cattle Cycles, 1930-1979

Cattle and Calves on Farms January 1



The shaded sections are periods of herd building.

Roughage components. — Projections of the demand for roughage[38] are made on the basis of feed required to produce a given quantity of beef, sheep, and mutton which will meet the projected demand for meat consumption over time. Projections of roughage demand were distributed among harvested roughages, nonrange grazing, and range grazing (fig. 5.8). Under these projections and assumptions, the demand for roughage in medium level projection would increase from 1,420 million AUM's in 1976, to 1,966 million AUM's in year 2030. Total roughage requirements will increase by 38 percent, while harvested roughage requirements will increase by 5 percent and all grazing by 54 percent. Harvested roughages expand at a slower rate than grazing because harvested roughages are competing for the use of the same land needed to produce food and feed grains.

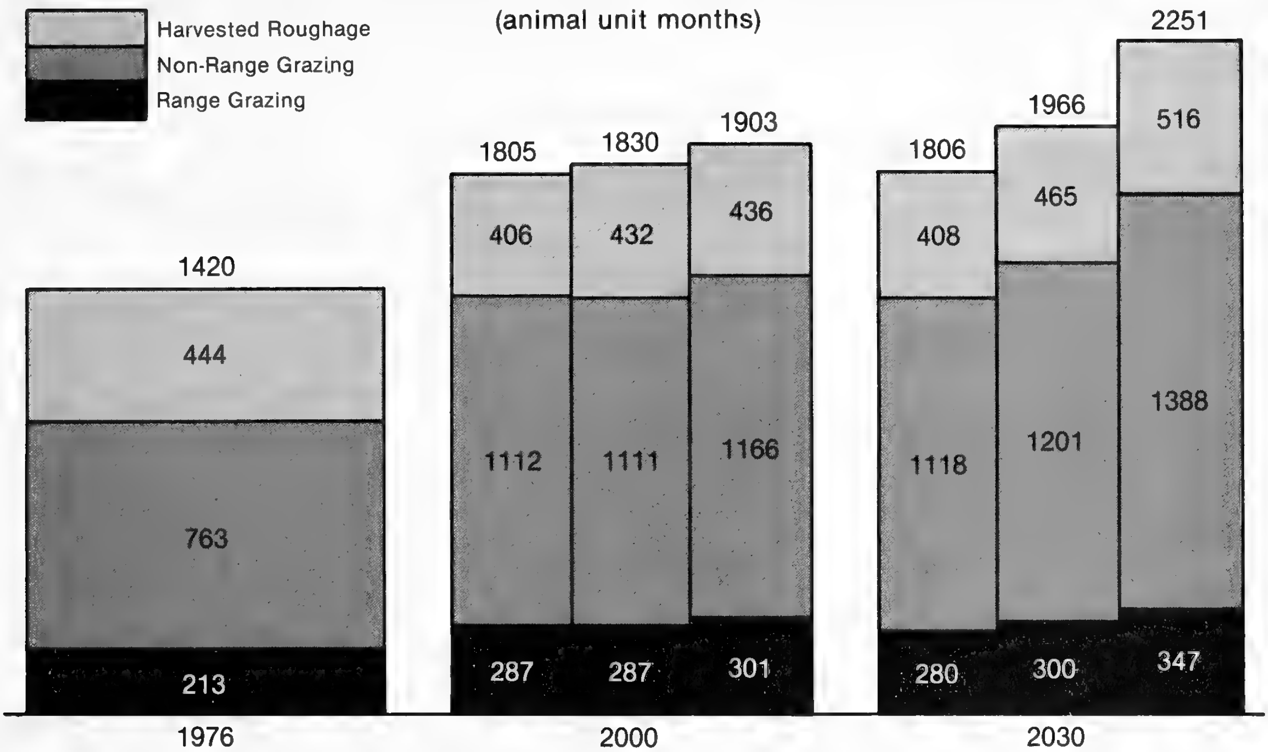
[38] For the analysis of this report, livestock feeds are grouped into two main categories — concentrates and roughage. Concentrates are grains and feed supplements. Roughage is harvested roughage (hay, silage, sugar beet pulp, etc.) and grazing. Grazing is subdivided into two groups — range and nonrange. Nonrange grazing is further broken down into three types — aftermath grazing (crop residues in field), cropland pasture (5-year rotation, irrigation, etc.), and other pasture (permanent pasture other than range).

Total grazing has been divided into range and nonrange grazing and the projected demand is shown separately (table 5.12). Under the medium level of projections, range grazing increases to 300 million AUM's in 2030 from 213 million AUM's in 1976, an increase of 41 percent. During the same period, 1976 to 2030, nonrange grazing is projected to increase by 57 percent. Total grazing (range and nonrange) of 1,288 million AUM's in 1990 and 1,501 million AUM's in 2030 will be required to meet the demands for beef and other grazing livestock products given the assumptions of the medium projections.

The projections of expanding grazing requirements are supported by analysis of the historical changes and trends in grazing by the various kinds of livestock (fig. 5.9). Total grazing use shows a downward trend during 1965-1978 because the decrease in grazing by dairy cows, sheep, and horses more than offsets the increase in beef cattle grazing during that period. However, the trends in demands for grazing by dairy cattle, sheep, and horses are expected to stabilize by 1985 and remain steady through 2035.[39] Demands for beef cattle grazing (the major determinant of grazing demand) will continue to rise. As a result, the trend in

Figure 5.8

Current and Projected Levels of Demand for Roughage Components



demand for total range grazing is expected to bottom out in the decade 1980-1990 and be upward thereafter through 2030.

Various rational explanations can be provided for the projected upward trend in demand for range grazing. Dairy production cannot be expected to continue to decline and so release grazing as in the past. Even though per capita consumption of milk is expected to continue to fall, the expanding population will require a higher level of milk production; that is, more dairy cattle will be needed by 2030. Therefore, only very small amounts of grazing, if any, now used by dairy cattle will be released in the future for beef cattle use. Sheep and horse populations may have reached their minimums; in fact, horse populations are presently increasing. Therefore, the shifting of grazing from these kinds of livestock to beef cattle use as done in the past may possibly not occur in the future.

[39] The magnitude of grazing use by any kind of livestock may decline to any number including zero over time, but grazing cannot be negative at any time. Therefore, the future grazing use trend is projected by using the exponential curve fitting technique. This technique restricts the magnitude of grazing to take only a positive or zero number.

Table 5.12 — *Projected demand for range and non-range grazing in the United States under alternative projections to 2030*

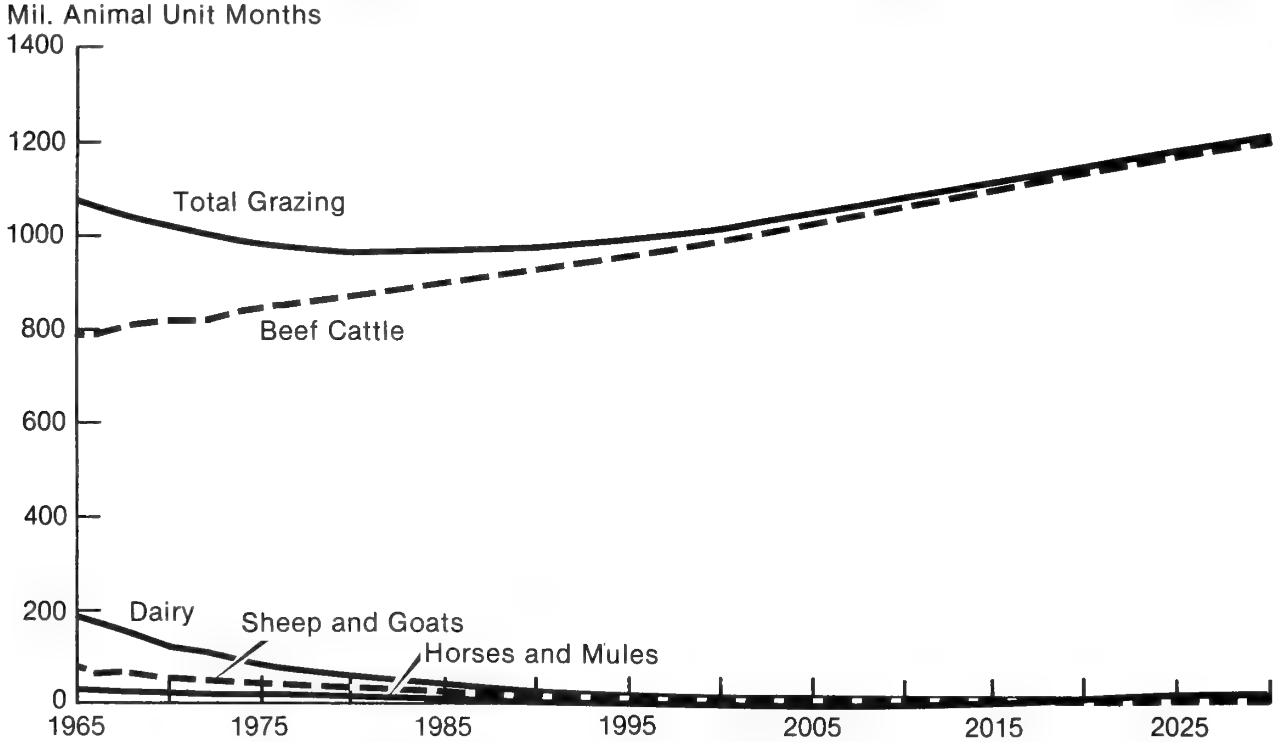
(Million animal unit months-AUM's)[1]

Projection level	1976	1990	2000	2010	2020	2030
	Range					
Low	—	275	287	284	282	280
Medium	213	270	287	290	295	300
High	—	277	301	313	329	347
	Non-range					
Low	—	1,036	1,112	1,136	1,130	1,118
Medium	763	1,018	1,111	1,158	1,179	1,201
High	—	1,042	1,166	1,250	1,317	1,388
	All grazing					
Low	—	1,311	1,399	1,420	1,412	1,398
Medium	976	1,288	1,398	1,448	1,474	1,501
High	—	1,319	1,467	1,563	1,646	1,735
	Range as percent of all grazing					
All levels	.218	.210	.205	.200	.200	.200

[1] An animal unit month is the amount of forage required by a 1,000-pound cow or equivalent in 1 month.

Figure 5.9

Historical Trend in Grazing by Type of Livestock and Extension of Trend to 2030



In addition, the heavy substitution of grains for grazing in beef production cannot be repeated. In fact, the desire for less fat in beef may result in less grain used in beef production, resulting in further increases in demand for grazing. Thus, increases in beef production will require additional quantities of grazed roughages.

Projected Regional Demands for All Grazing

Projections of demand for grazing by geographic regions are based on the distribution of the demand for all grazing (table 5.13). Projections were based upon the traditional pattern of grazing and do not include alternatives that consider the relative production capabilities and costs of grazing among the regions. It is assumed that the regional distribution of demand for all grazing will be the same for both range and nonrange grazing.

Table 5.13 — *Indexes of projected demand (medium level) for grazing by sections and regions in the contiguous States*

(1976 = 100)

Section and region	1976	1990	2000	2010	2020	2030
North						
Northeast	100	133	138	138	138	138
North Central	100	124	129	132	135	137
South	100	153	170	177	181	185
Rocky Mountains and Great Plains						
Rocky Mountains	100	108	128	132	134	136
Great Plains	100	137	148	154	158	161
Pacific Coast	100	122	131	135	137	138
Total	100	132	143	148	151	154

Local Demand and Federal Lands

The discussions and analysis of demand for range grazing up to this point have been solely in terms of the relationship to demand for food at the national level. However, since grazing as a source of livestock feed is geographically fixed, there are important aspects of local demand for range grazing which differ from national and regional demands. In general, local demand for range grazing responds to the local mix and availability of other livestock feeds. Range grazing is currently integrated into the balanced operation of each individual cattle and sheep producing operation. Changes in the amount of range grazing or inability of the range to increase production relative to increases in total demand for grazing will adversely impact livestock producers using range grazing.

Importance of Federal lands. — Livestock grazing on Federal range is of major importance in the livestock production process in the 11 western States, where 90 percent of the Federally-owned grazed lands are located. The quantity of grazing permitted is controlled by the capacity of the land to sustain livestock grazing in relation to other use requirements.

Much of the Federal land grazing is seasonal and falls into a natural complementary role in year-round cattle or sheep production enterprises. The Federal lands provide feed in one or more seasons of the year, often when forage on associated privately owned lands is not available, and the rancher provides feed for the remainder of the year from the privately owned lands. Since this complementary use of land in private and Federal ownership follows the natural production capacity of the land, it represents a more efficient use of grazing resources than can be accomplished by other combinations of land use. Thus, the efficiency of the livestock industry in areas with large acreages of Federal land open to grazing has a strong relationship to Federal range grazing. In such areas, the demand for Federal range grazing is very strong.

The limiting factor in many local areas (especially in the West) that determines the operating size of many livestock operations is often the amount of Federal range available during seasons of feed shortage on the privately-owned range.[40] Such critical periods may occur in the fall prior to hay feeding, in the summer when forage on private lands is low in nutritive value compared to forage on Federal ranges at higher elevations, or when private lands are needed to produce crops for winter forage. The relationship of range grazing on Federal lands is very strong in many local areas, and variations in the supply of this source of grazing have a significant impact on the livestock industry in those areas. Alternative sources of feed are available to the private sector in some situations, while some livestock operations depend wholly upon the Federal lands for their livestock forage. While the growth rate of the cattle industry overall might be reduced, the industry can make adjustments to restrictions in the quantity of Federal grazing available.[41]

Much of the grazing on Federal lands, such as that in this high basin, is seasonal, taking place only in the warm months of the year.

The sheep industry is especially dependent upon Federal grazing lands. Nearly half of the sheep producers that own more than 2,500 head of sheep use Federal range, which provides about 42 percent of their annual forage requirements. The cattle industry and production of beef is widely distributed through the United States, and the Federal lands provide a minor portion of the total feed consumed by beef cattle. While the Federal land relationship to cattle production is not as dramatic as with sheep, the relationship between sources of feed and cattle production is often very important in local situations and to individual users throughout the western States. Federal land has minor local impacts on the livestock production process outside the western States.

[40] Bartlett, E. T., L. E. Mack, Garth Taylor. Economic effects of reductions in Federal grazing upon the economy of Colorado. Unpublished manuscript. June 1979.

[41] Godfrey, E. Bruce. Private adjustments to changes in grazing on public lands. Unpublished manuscript prepared under contract by Utah State University for RPA, Forest Service. May 1978.

Demand in Alaska and Hawaii. — In Alaska, 10 to 13 million acres of grassland have been estimated to have range potential for cattle, sheep, and horses.[42] However, the prospects for increasing Alaskan production of red meat from cattle and sheep and, hence, demand for range grazing are very low.[43] The lack of development of Alaska's latent agricultural regions and the absence of any organized effort to promote the required infrastructure preclude the development of an expanding meat production industry. Development of meat production for subsistence from wild game is not expected to respond to changing imported meat costs until there is a philosophical change in wildlife management which accommodates a staging of resources and harvest techniques to inaugurate a maximum "sustained yield harvest" of meat from "wild" animal species. Moreover, even if commitment of the public and private sectors were made at this time (1979), at least 10 years would be needed to stage resources, institutional and agency programs, philosophical and technical concepts, and personnel and experience sufficient to initiate the needed flow of knowledge, technology, and services. A second decade would be needed to stage significant production capability and infrastructures.

The primary basis for the Hawaiian beef industry is the utilization of some 1.3 million acres of grasslands (pasture and range).[44] Increases in the demand for grazing will primarily be met through improved management. However, the higher demand for red meat will be met primarily through increased shipment of meat to Hawaii from other States.

Potential Supplies of Grazing

The quantity of grazed roughages needed to meet the demands for livestock feed is a function of the available feed sources. Grazed roughages can be produced from both nonrange and range sources.

Nonrange Sources

Data on nonrange sources of grazing in the United States are limited and incomplete. The following analysis is constructed from a variety of sources and reconciled with data on total grazing and range grazing.

Part of the increasing demands for livestock products and the subsequent increase in demand for grazed roughages can be met by several nonrange grazing alternatives including: (1) Use of more cropland for grazing, (2) grazing of crop aftermath, and (3) increasing pasture and cropland pasture yields. Each alternative offers opportunities to increase the amount of grazed roughage from nonrange lands.

Cropland used for grazing. — Shifts of land use between crop production and cropland used for pasture have historically occurred in response to changing markets and governmental policies and programs. In 1910, cropland used for pasture amounted to about 84 million acres and this declined to a low of 66 million acres in 1959. By 1969, total cropland pasture had increased to 88 million acres, and then declined to 84 million acres in 1975.[45]

There is a potential to divert additional cropland acreage from crop production to livestock grazing.[46] For example, Federal grain production control programs whereby farmers are paid to divert cropland from grain production can encourage the use of cropland for grazing. The cost of such a change is the difference between the net return of producing crops and the net return for pasture. The amount of such increased conversion is limited. Much of the diverted acreage is controlled by farmers who either do not own cattle or sheep or who may not wish to increase the size of their livestock operation. And finally, the land available for diversion is frequently unfenced, and fencing represents a significant cost which could not be recovered in the brief time the area was grazed.

The amount of land under these programs varies from year to year. In 1972, nearly 60 million acres were withheld from grain production. In the 1973-1977 period, the program was smaller or nonexistent. In 1978 and 1979, the program again involved substantial acreages. Assuming about 40 percent of the acreage diverted in 1972 to be representative, there could be approximately 24 million acres of additional land available for grazing.[47] This land is estimated to have a potential production of 4.6 to 9.3 AUM's per acre or 110 to 220 million AUM's annually. However,

[42] Tomlin, D. C. Grazing lands of Alaska. Alaska's agricultural potential. Alaska Rural Dev. Counc. Publ. N.1. (as cited in USDA appraisal 1980, Rev. draft, Part I). Soil and Water Resource Conservation Act. 1979. U.S. Department of Agriculture, Soil Conservation Service. 1979.

[43] Burton, Wayne E. Range grazing demands in Alaska. Unpublished manuscript prepared under contract by the University of Alaska for RPA, Forest Service. December 1977.

[44] Wilson, C. Peairs. Range grazing demand in Hawaii. Unpublished manuscript prepared under contract by the University of Hawaii for RPA, Forest Service. May 1978.

[45] U.S. Department of Agriculture. Agricultural statistics 1977. Unnumbered publication, 614 p. Washington, D.C. 1977.

[46] Gilliam, Henry C., Jr. Beef cattle production potential of set-aside land. U.S. Department of Agriculture, Economic Research Service, Washington, D.C. ERS-530. November 1973.

[47] Johnson, James, and Milton H. Erickson. Commodity program provisions under the Food and Agriculture Act of 1977. U.S. Department of Agriculture, Economic Research Service (now Economics, Statistics, and Cooperatives Service), Agric. Econ. Rep. 389, 31 p. 1977.

it is expected that little, if any, of the potential acreage will be used for grazing. Grazing use is not likely because of the large annual variations in the diverted acreage and because of the increased demand for other uses of cropland. Thus, it is expected that no more than 84 million acres of cropland will be used for pasture in future years.

Pasture acreage. — It is possible to convert croland to pasture and thereby increase the acreage and production of grazed roughages from pastures. Conversion of cropland to pasture to meet livestock feed needs, however, is not feasible under the alternative situations projected. Crop production must increase by 50 to 97 percent to meet basic food needs during the same time that livestock roughage production is increasing. In addition, because of nonagricultural uses, less total cropland will be available. Since the conversion of cropland to pastureland is not likely to occur in a significant amount in the future in this analysis, the pasture acreage is assumed to remain constant through the 1976 to 2030 period.[48]

Crop aftermath. — Crop aftermath is that portion of the plant left in the field after the primary harvest. The amount available depends on the crop, production systems, and the demand for that crop rather than any response to the need for livestock feed. Production of hay, for example, results in considerable aftermath grazing while production of corn silage yields very little aftermath. At present, grazing of aftermath is a common practice in many areas and expansion of aftermath grazing does represent an opportunity to provide additional feed as feed production costs and demands for feed increase. The role of aftermath grazing in production of cattle and sheep is uncertain. Changes in the supply of aftermath available for grazing are a function of the crop-producing system and is not derived by the demand for grazing. Currently, an estimated 14 million AUM's of grazing in the form of aftermath, or 2 percent of all nonrange grazing, are consumed. The increased quantity of aftermath grazing is assumed not to exceed 5 percent (60 million AUM's) of nonrange grazing by 2030.[49]

Increasing pasture and cropland pasture yields. — Because the acreages of pasture and cropland pasture are very unlikely to increase, greater amounts of roughages from nonrange sources must be achieved through increased yield per acre. Increased herbage yields from pasture and cropland pasture are feasible. The production of dry matter on grazing lands in the humid, temperate climates of the United States can be increased as much as three times by improved practices.[50,51]

Increased production from grazed roughages can also be achieved by better management of the livestock and livestock use of the grazing lands as well as through improved quality.[52] However, all such improvements are included in this analysis as an increase in dry matter per acre and, hence, as increased animal unit months of grazing per acre.

Cropland pasture on 84 million acres produced 385 million AUM's of grazing in 1976 with an average yield per acre of 4.6 AUM's of grazing (table 5.14). Projected increased yields per acre of 70 and 79 percent by 2000 and 2030 are assumed. The high yield level of cropland pasture, both current and projected, reflects the high productive capacity of cropland relative to other pasture. Cropland pasture also includes irrigated cropland pasture. Because of the basic higher productive capacity of cropland pasture, irrigation, and the availability of the means to further increase production via irrigation and fertilization, it is expected that cropland pasture will yield higher amounts of forage.

Pasture is the permanent grazing area which is not classified as range. Pasturelands are generally more productive than range but generally less productive than the croplands and the average yield per acre in 1976-78 was only 70 percent of the cropland pasture yields. It is estimated that pasture yields could be increased threefold, to over 8 AUM's of grazing per acre under intensive management and fertilization.[53] This estimate is optimistic because it was estimated during a period when the cost of fertilization was low. Because the higher costs of energy are reflected in fertilizer prices, the feasible level of fertilization will be lower than previously estimated. Pasture yields are expected to increase during the 1976-78 to 2030 period but at a slower rate than cropland pasture.

[48] The analysis does not consider the conversion of range to pasture. Increased outputs from range are considered as a function of range improvements and not as a conversion to pasture.

[49] Higher estimates of aftermath grazing are available. A huge quantity of roughage from corn, milo, wheat, etc., remains in the fields. However, removal of this roughage requires replacement of nutrients by fertilizers of increasing cost or the roughage may become an energy source. Existence of these factors prompted use of a conservative estimate of livestock use of crop aftermath in this analysis.

[50] Bula, R. M., U. L. Lechtenberg, D. A. Holt. Potential of temperate zone cultivated forages for ruminant animal production. In: Potential of the world's forages for ruminant animal production. 91 p. Winrock International Livestock Research and Training Center, Morrilton, Ark. p. 14, 15, and 27. September 1977.

[51] Martin, J. H., W. H. Leonard, D. L. Stamp. Principles of field crop production, McMillan, N.Y. p. 272. 1976.

[52] Hodgson, Harlow J. Food from plant products — forage. Proceedings of Symposium on complementary roles of plant and animal products in the U.S. food system. November 29-30, 1977. National Academy of Sciences, Washington, D.C. p. 56-74. 1977.

[53] Hodgson, *op cit.*

The production of herbage from pastures in the humid eastern half of the country can be increased by as much as three times with improved practices.

Pasture yields are assumed to increase by 50 percent or to 4 AUM's of grazing per acre by 2030. By 2030, pasture yields per acre would be less than 50 percent of cropland pasture yields. Under these yield estimates, pasture could provide 454 million AUM's of grazing by 2030.

Range Sources

Range grazing trends. — The supply of range grazing has historically followed the pattern of changing beef cattle numbers and the price relationships of range grazing to other livestock feed sources. Range grazing increased as the West was settled and peaked during the food crisis of World War I, especially on Federal lands. Thereafter, it stabilized at a somewhat lower level. From the 1940's until the present, most of the increases in livestock feed for the rapidly growing beef cattle numbers were supplied, not by range grazing, but by increased use of grain and by roughage sources formerly used for dairy cattle, sheep, and horses. Thus, the production and use of range grazing has been relatively unchanged. In 1976, range produced about 213 million AUM's of livestock grazing, the same produced in 1970. Extending this 1970 to 1976 trend to 2030, the supply of range grazing would remain about 213 million AUM's of grazing if the investment in range improvement is not increased above the current level.

Biological potential. — The Nation's range has the physical capacity to produce more grazing to meet projected demands. The ultimate biological potential production from the range has been estimated at 566 million AUM's, more than 2½ times the 1976 supply level of 213 million AUM's. This could be achieved by applying intensive management levels on all of the more than 1 billion acres of range. This production level (566 million AUM's) is not attainable as a practical matter because much of the range is used for other purposes, such as timber production; the increased management for range grazing purposes would adversely affect production of timber and other range outputs.

A more useful estimate of biological potential is derived by considering only that portion of the range which is currently being grazed (789 million acres) as available for intensive management. Under intensive management, improved grazing systems and range developments are used to maintain and improve the condition of the range ecosystems. Since ranges in less than good condition produce less forage than those in good condition, improvements can be reasonably expected to increase production. An illustration of this that does not consider the economic feasibility of such improvements follows:

The largest rangeland ecosystem, plains grasslands, occupies 175.2 million acres and has a natural average potential production of 1,016 pounds per acre (table 2.6). About 25.8 million acres are in good condition, 59.9 million acres are in very poor condition (table 5.2). If the 172.4 million acres grazed in this ecosystem were improved to good condition, thereby achieving an average production of 1,016 pounds per acre from all lands in the ecosystem, the expected increase in production would be 21.2 million tons of herbage and browse (table 5.15). This is a third more than the 66.4 million-ton production now obtained from the ecosystem. Similarly, production could be increased from the smaller but more productive prairie ecosystem by 14.3 million tons, from sagebrush by 13.8 million tons, and from desert shrub by 1.4 million tons.

The biological potential for grazing on the Nation's ranges is more than two and a half times current production levels.

Table 5.14 — *Non-range grazing, 1976-78 average and projected grazing capacity in the United States for 2000 and 2030*

Non-range grazing	1976-78 average			2000		2030		Percent change in yield per acre	
	Million acres	Million animal unit months [1]	Animal unit months per acre	Million animal unit months	Animal unit months per acre	Million animal unit months	Animal unit months per acre	1976-8 to 2000	1976-8 to 2030
Pasture	112	302	2.7	423	3.8	454	4.0	40	50
Cropland pasture	84	385	4.6	655	7.8	687	8.2	70	79
Aftermath	—	14	—	33	—	60	—	—	—
Total	196	701	—	1,111	—	1,201	—	—	—

[1] An animal unit month (AUM) is the amount of forage required by a 1,000-pound cow or equivalent in 1 month.

Table 5.15 — *Present and expected production of herbage and browse and range grazing on the two largest grassland and shrubland ecosystems*

Ecosystem	Area grazed	Present production		Potential production[1]	
		Herbage & browse	Range grazing	Herbage & browse	Range grazing[2]
	Million Acres	*Million Tons*	*Million AUM's*[3]	*Million Tons*	*Million AUM's*
Plains grasslands	172.4	66.4	54.3	87.6	98.6
Prairie	39.1	50.6	45.4	64.9	73.0
Sagebrush	116.8	46.2	24.6	60.0	67.5
Desert shrub	57.1	5.7	2.8	7.1	8.0
Total	385.4	168.9	127.1	219.6	247.1

[1] Production expected if all lands grazed were in "good" condition.
[2] Assumes that 45 percent of the herbage and browse would be available as forage if the range were in good condition and that 1 ton of forage equals 2.5 AUM's.
[3] An animal unit month (AUM) is the amount of forage required by a 1,000 pound cow or equivalent in one month.

Thus, the plains grasslands, prairie, sagebrush, and desert shrub ecosystems could provide a total of 219.6 million tons of herbage if all lands grazed in those ecosystems were improved to good condition. Assuming 45 percent of the herbage and browse is available, this production is the equivalent of 247 million AUM's of grazing, 120 million more than the ecosystems now produce. In other words, these four ecosystems, which now supply about 60 percent of the Nation's range grazing, could in themselves provide almost as many AUM's of range grazing as are projected to be needed in year 2000 without increasing area grazed in the ecosystems if all of their acreage were improved to good condition, a probability highly unlikely because of economic considerations.

The biological potential indicates only the physical capacity of the ecosystem for producing forage. Additional grazing above the current level is possible only at increasing costs because more intense management, technology, and improvements are needed. The physical limits of range grazing supply do not restrict the demand, but the question remains how much range grazing can be increased and at what cost. The per unit costs of range grazing at biological potential are likely to be more than double the current costs. Such cost levels would exceed the amounts that could be recovered and would probably result in the use of nonrange sources of feed for livestock.

Institutional constraints such as maintenance of undisturbed ecosystems, perpetuation of all plant and animal species, and multiple use constraints may often prevent reaching the biological potential on range ecosystem. Constraints against application of certain technology may further limit achievement of the biological potential, primarily by increasing the cost of range management.

It is possible that production per acre on range will increase at a slower rate than that shown for cropland pasture and other pasture (table 5.14). Much of the range is in the semiarid areas of the United States. In the drier areas, range yields can be very low with very limited opportunities to increase output to any significant extent. However, the yields and responses of the

range ecosystems vary widely. Range includes land in humid areas where current yields per acre reach 3 AUM's, and under intensive management, yields of 6 AUM's per acre are expected by 2030.

Projected Demand and Supply Relationships

Demand and Supply Comparisons

Meeting the projected demands for range over the next 50 years will require a substantial increase in supply above the current level. Demand under the medium projection series is estimated at 300 million AUM's by 2030 (table 5.12), 87 million AUM's above current supply (fig. 5.10). Such a deficit would result in a rise in the production cost of beef and other livestock products or result in a reduction in the amount of beef consumed per capita because of increased consumer prices for beef. Under the assumptions of the high projections, demand increases to 347 million AUM's, while the low projections assumptions result in a 280 million AUM estimate.

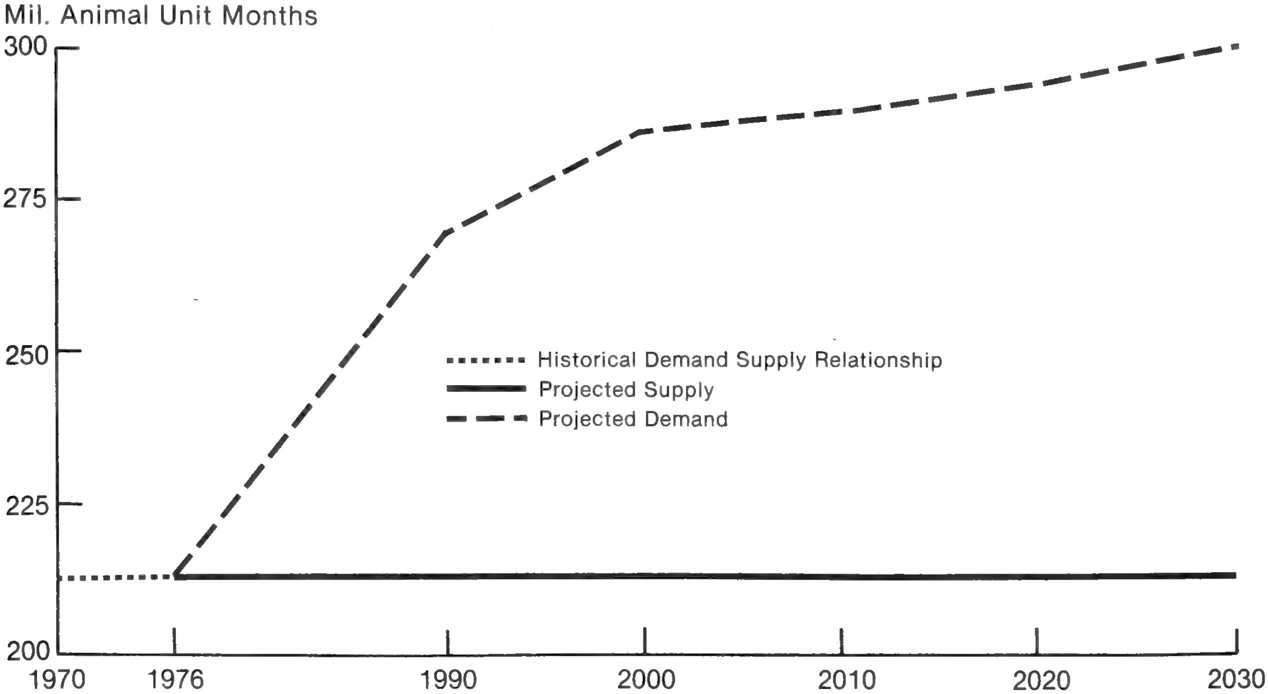
Another focus of the demand/supply relationship is the annual variability of grazing supplies as opposed to the constant need for livestock to have feed. Because of the variability in growth of demand and the time lag and uncertainties of range production, the costs and benefits of adequate supplies versus supply deficits become important. If deficits are to be avoided, the range grazing supply must be related to the peak demands which occur with the high animal numbers at the peak of the cattle cycle. The development and maintenance of range grazing supplies in the semiarid areas of the West are particularly critical because of the magnitude of range grazing's contribution to livestock production in that area. The relatively long time required to modify range supplies after investments are made (3 to 10 years may be required to achieve production increases) also supports the need to plan for peak periods.

Optimization of Grazing

The concept of grazing output optimization integrates the cost of production and the value of production at the margin. The optimization of grazing requires the condition of equalization of the cost

Figure 5.10

Comparison of Current Trend in Supply with Projected Trend in Demand for Animal Unit Months of Range Grazing



incurred and benefits derived from the production of an additional unit of AUM of grazing to the nation. So, the determination of the optimum grazing necessitates the estimate of the marginal cost (i.e., the ratio of the increase in cost to the increase in output) and the benefit (i.e., the AUM value) of grazing at different levels of demand and supply.

The estimated value for an AUM of grazing in 1976 is $4.22 and would increase (in constant dollars) to $6.12 by 2030. The marginal cost is estimated at $4.46 in 1976 for a production level of 213 million AUM's of grazing and would increase to $5.00 for a production level of 365 million AUM's. These estimates indicate that the projected demand of 300 million AUM's, medium projection, or 347 million AUM's high projection, for 2030 could be supplied with economic justification, because the estimated value of grazing covers the cost of producing this level of AUM. Annual production up to 365 million AUM's falls within the range of economic feasibility, but increasing production above 365 million AUM's would increase costs more than the economic value of AUM's produced.

Estimated cost of supplying the different levels of range grazing indicates that the nation has the capability to meet expected demands. Achieving this level, however, will require investments in management and range development programs to increase the supply of range grazing above the current level. However, if grazing could be distributed across the rangeland in the most advantageous way from both economic and environmental points of view, the cost of producing the current level of grazing would be significantly reduced. Such a distribution has been analyzed as a part of this assessment effort.[54] Increased management intensity and grazing would occur on desirable locations, and grazing would be eliminated from marginal or undesirable locations. Average production on the acreage grazed would increase by 85 percent, from 0.27 to 0.50 AUM's per acre per year. The most significant changes were suggested for private lands and the Federal lands administered by the Bureau of Land Management.

Impact of Increased Energy Prices

Increases in the prices of energy used in agricultural production may change the projected economic supply of range grazing. Increases in energy prices increase the production costs of all agricultural production including range grazing. It is estimated that a doubling of real energy prices could result in on-farm agricultural production costs rising by 8 percent.[55]

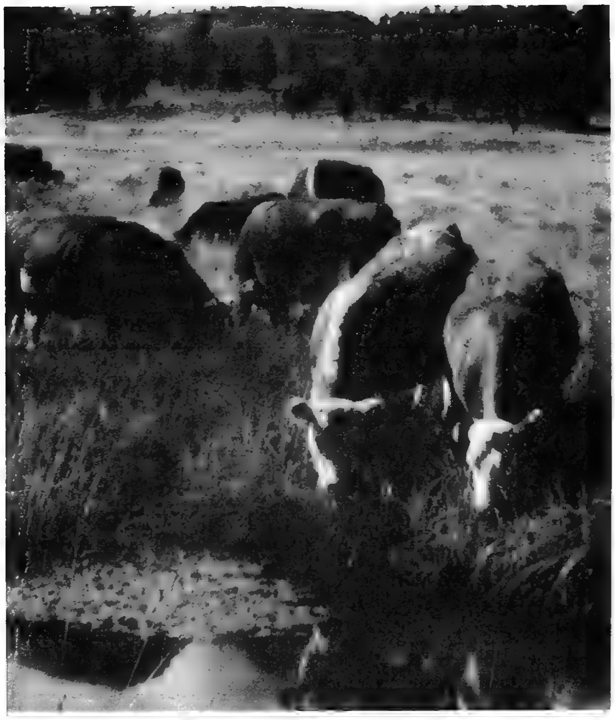
Energy prices will be significant to projected range grazing only if range production costs increase at a different rate than production costs of other sources of livestock feed. The increased costs of energy will have the largest impact on costs of producing those feeds using the most energy (particularly fertilizer) such as the feed grains. Therefore, the first impact of increased energy costs is to increase the cost of grains relative to forages, and hence lead to increased use of grazing in the production of beef.

Increased energy costs also are expected to modify the geographic distribution of grazing at economically feasible levels. For example, those areas with lower levels of response to fertilization become less competitive as fertilizer prices increase. As the price of fuels increases, range practices requiring large inputs of such fuels will become more expensive. Similarly, grazing areas in more remote locations requiring the use of vehicles over long distances also become less competitive as the price of fuel for these vehicles increases.

Range livestock production is a relatively low consumer of energy compared to production systems using large quantities of grains. Forage production on range is largely a function of natural processes using energy from the sun, whereas grain production depends on cultivation activities using high-cost fossil fuel energy. Therefore, one way for the livestock industry to meet production and income goals in the face of higher energy costs is to produce red meat by more effectively utilizing range and other roughages and by reducing the use of grains. Thus, energy price increases will result in grazing, including range grazing, being an increasingly advantageous economic situation. Eventually, the production limitations of the land use for grazing, and especially range grazing in the more arid areas, can be expected to equalize the energy cost relationship as more intensive management is applied. Therefore, the initial effect of energy price increases will increase the relative demand for range grazing. Later, as the resource capability of the range is utilized, the increased demand for livestock feeds will have diminishing impact on the demand for range grazing.

[54] Ashton, Peter G., James B. Pickens, Coryell Ohlander, and Bruce Benninghaff. Many resources, many uses . . . a system analysis approach to current and future renewable resource development. Presented at the 15th Annual American Water Resources Association Conference on Water Resources Management in a Changing Society. Las Vegas, Nevada, September 24-28, 1979. Estimates are derived from use of this multi-resource interaction, linear programing model.

[55] U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service. Energy policies: Price impacts on the U.S. food system. Agric. Econ. Rep. No. 407, 44 p. 1978.



Rising energy costs are likely to increase the demand for range forage, the product of natural processes using energy from the sun.

Environmental Constraints

Producers of livestock could be affected by several forms of environmental constraints, including limitations on the use of pesticides and feed additives, restrictions on tillage practices, restrictions on soil erosion, controls upon irrigation water discharge, and animal waste disposal. Most of the environmental constraints would favor increased feeding of forage and greater range grazing and cause decreases in use of grains. However, rising energy prices may mitigate part of the restrictive impacts of stricter environmental controls upon waste disposal from animal feedlots. Manure may become an economical substitute for high energy-using chemical fertilizers, thus solving the disposal problems.[56] Similarly, environmental constraints and higher energy costs will impact on pasture and range improvements and vegetation manipulation. In any event, while it is evident that tighter regulations can be expected to increase the cost of meat to the consumer, it is not certain to what degree the mix of grain, pasture, and range used will be affected. The general conclusion, however, is that environmental constraints will improve the economic advantage of grazing relative to grains and harvested forages as sources of livestock feed.

[56] Hodgson, H. J., and R. E. Hodgson. Changing patterns in beef cattle production. Agri. Sci. Rev. 8(4): 16-24. 1970.

Federal Lands

Wilderness. — Classification of Federal land areas into wilderness under provisions of the Wilderness Act of 1964 has had some effect on Federal range grazing. Although the Act permits grazing to continue where it was established prior to the effective date of the Act (September 3, 1964), meeting other requirements of the Act has been somewhat inhibiting to range use of these areas. Proposed range developments in wilderness must be limited to those that leave the classified areas essentially unimpaired for future use and enjoyment as wilderness. A 1978 study of National Forest System roadless areas (i.e., RARE II) for prospective classification into wilderness indicated a reduction in grazing of about 500,000 AUM's may occur if all the studied areas were classified as wilderness.

Endangered species. — Another factor potentially restrictive to achievement of Federal range grazing potential is associated with requirements of the Endangered Species Act of 1973. Some plants, proposed for classification as endangered and threatened, are present today because of grazing; the habitat for others can be improved with improved grazing management; while other species require total protection from grazing. To meet the provisions of the Act, all Federal programs must be carefully analyzed to determine the potential for harm in each situation and to provide for protection and conservation of the classified species. To date, the impact upon Federal range programs has been minimal because none of the plants (as of July 1, 1979) classified as endangered or threatened has been so classified because of grazing. The potential impact will depend upon the needs of species classified and the nature of future programs.

Wild horses and burros. — A potentially inhibiting situation which would constrain expansion of grazing for livestock applies only to Federal lands administered by the Forest Service and the Bureau of Land Management. The Wild Horses and Burros Protection Act of 1971 directs that wild horses and burros be considered an integral part, or component, of the natural system on the public lands where they were found as of 1971. Forage and other habitat requirements for wild free-roaming horses and burros in established territories must be considered when use of the range is being allocated. However, the 1976 wild horse and burro population consumed less than four-tenths of 1 percent of all range grazing and less than 5 percent of the grazing on Federal lands administered by the two agencies.

Opportunities for Increasing Range Grazing

Management Application Opportunities

The amount of range grazing can be expanded by improving grazing management systems, installing structural and nonstructural range improvements, and plant control. The increase in range grazing must be related to both the demand for range grazing and the demand for improved environmental quality.

Increased supplies of range grazing can be achieved by applying existing range management technology. Some of the primary management tools are (1) grazing management including kinds and classes of livestock, stocking rates, grazing seasons and improved systems of grazing; (2) range improvements including water development, fencing, seeding, and undesirable plant control and pest management and control using mechanical, fire, chemical, and biological methods; and (3) through coordination with others uses.

Better range condition and stewardship of the range resource can be achieved through improved management. The science of range management has developed under a philosophy of stewardship—preventing damage to public and private resources and restoring depleted rangelands.[57,58,59] Through proper management, range can be used perpetually for grazing while simultaneously providing the public with high-quality air and water, open space, and recreation.[60]

Grazing systems are one means for getting the kind of grazing desired throughout a management area. Some simple systems entail no more than turning livestock into a fenced area, providing them with water and salt, and removing the animals when the vegetation has been grazed to a desired amount. Other systems are quite complex and involve rotating livestock among several pasture units during a given grazing season with the order of rotation varied between years.

Improved grazing systems designed to consider the multiple requirements of soil, vegetation, livestock, wildlife, and nongrazing uses of the range usually will support more grazing use over time than the grazing management currently practiced in most areas. Initiation of improved range management programs on ranges suffering from too many livestock and too little management can produce significant increases in forage and environmental quality at low cost.

Providing forage in relation to the physiological needs of both the plants and grazing animals is one way toward increased effectiveness through management. An example is managing range in a manner which provides forage for elk winter use, deer spring use, and fall livestock use, and simultaneously maintaining a high ecological condition. Grazing systems and related improvements must be designed to meet specific site requirements and must be applied accordingly to economic feasibility, site production potential, and vegetation needs. As range management intensifies, better care and management of the environment will result. Management systems must consider costs of the predicted outputs, i.e., cost-effectiveness is an important criterion of successful grazing systems.

Structural improvements, such as fences and water developments, are designed to control the movement and distribution of livestock and facilitate their handling. Nonstructural improvements are practices, such as seeding, fertilization, and plant control, that are designed to increase production, nutritional quality, and availability of forage.

Some rangeland is currently underused or not used at all because of inadequate drinking water for livestock. Under intensive and improved management systems, these ranges often can be brought into productive use by constructing fences and developing additional water supplies.

Seeding of palatable grasses and legumes also provides significant opportunities to increase forage production. Seeding can be used to hasten rehabilitation of depleted ranges, replace less palatable or less desirable species, or provide forage at critical seasons. For example, crested wheatgrass is often seeded to provide palatable early spring forage so that grazing of native range can be delayed until the native plants are more fully developed and better able to withstand grazing.

Control of poisonous plants, such as larkspur in the foothills and mountain grasslands of the Rocky Mountains, can open large areas to early summer grazing by cattle. Another opportunity to provide additional range forage, especially in the West, is the control of shrubs such as mesquite, sagebrush, and juniper that have invaded grasslands.

Insects and diseases consume large amounts of vegetation and limit seed supplies of many range plants. Integrated pest management programs, though now in their infancy, have promise to enhance range yields.

[57] Roberts, Paul H. Hoofprints on forest ranges—the early years of National Forest range administration. 151 p., illus. San Antonio, Texas. 1963.

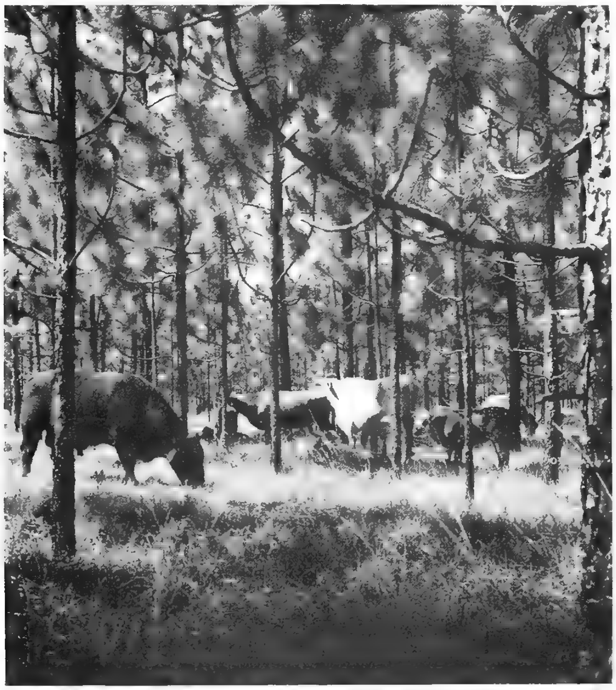
[58] Stoddard, Laurence A., and Arthur D. Smith. Range management. Ed. 2, 433 p., illus. New York. 1955.

[59] U.S. Department of Agriculture, Forest Service. The western range. Senate Doc. 199, 620 p. 1936.

[60] Lloyd, R. Duane, et. al. Range ecosystem research: The challenge of change. U.S. Department of Agriculture, Agric. Info. Bull. No. 346, 26 p. 1970.

Good fencing is an important tool in managing livestock grazing on range.

Forest management practices can be modified to increase the production of forage from forest lands.



Use of fertilizers in native range, though often considered, has not been extensive in the past. It is not expected to be a widespread activity in the future because of continuously escalating costs of inorganic fertilizers in relation to benefits. However, fertilization does offer limited opportunities to increase forage, especially on private lands with high productivity and where livestock can be very intensively managed.

Significant opportunities to increase range grazing occur on portions of the 482 million acres of commercial forest land. Commercial harvesting of mature tree stands will often result in temporary (5 to 10 years) production of grasses, shrubs, and forbs that are palatable to livestock. Intensive timber management practices such as thinning, pruning, and site preparation, can be modified in scope, timing, and intensity to increase the amount, and to extend the period of forage production throughout the timber rotation as well as improve the forest stand. There are some spinoffs from grazing in the forest that are advantageous to timber production. When properly managed, livestock can benefit the forest through consuming vegetation that competes with trees. Improper or uncontrolled grazing, of course, can seriously jeopardize the timber resource. It is imperative, therefore, that livestock grazing in forest stands be planned, controlled, and coordinated so that use of the forage resource will not impair the productivity of the land.

Not only is grazing compatible with other uses on vast acreages of public lands, range grazing and associated activities can be used to benefit other resource uses. There can be both economic and social benefits in multiple-use management of these lands. In California, for example, cattle and goats are used to help maintain fuel breaks in the chaparral-type to reduce wildfire hazards. Controlled grazing is often used to

maintain grassy and shrubby openings in forested areas, thus improving habitat for certain species of wildlife such as wild turkey, white-tailed deer, and quail. Many range improvements designed to improve livestock grazing also improve habitat for wildlife. Fences built for livestock control provide perches for a variety of birds and small mammals, and are frequently used to help manage hunter use. Water developments, range seedings, and prescribed range burns enhance the value of range for upland game birds. Livestock production programs geared to minimize energy costs have resulted in considerable savings of water per unit of meat produced, an important consideration in water-short areas of the western United States.[61]

The key to wise use of the range is sound and coordinated land management planning. Land management planning is predicated on the basic premise that a mutuality of private and public interests exists to preserve and develop the resources of the land. Conservation of the range is an economic and political issue dealing with the question of allocation of resources between or among generations over longer periods of time. Private owners usually adopt range improvement practices in response to the expected economic gain resulting from the practices. Because their perceptions and interests do not extend as far as do those of nations, private owners may tend to discount the value of future range production more than is consistent with the national interest. That is, the public may have a greater appreciation for the conservation of the soil and vegetation today to protect the potential for output in the year 2030 than do the private owners with their need for current income. While meat production is a primary factor in the demand for range, stewardship of the range resource is also a matter of vital public interest and must be considered as well as the demand for meat.

Technical Assistance

The U.S. Department of Agriculture, through its research, technical assistance, and extension programs, works closely with the owners and managers of non-Federal lands to improve the productivity and profitability of their operation. As a result, significant progress has been made in the appreciation of sound range management on non-Federal lands. However, range scientists recognize that much can still be done to improve range resources by using presently available technology.

[61] Ward, 1976, *op. cit.*

Modification and intensification of the technical assistance process can help materially in using available technology to achieve more effective range management. Range management systems make their greatest contributions to the conservation and productivity of range resources if they are well planned, efficiently installed, and adequately maintained. Strengthening the technical assistance program in all three phases of range management systems will result in increased forage and meat production as well as maintaining range resources for future generations.

Technical assistance appears to be especially needed for forested ranges in non-Federal ownership. A 1974 U.S. Department of Agriculture report recognized, "Though the mechanism appears to be available, the forest-range assistance program is not as fully operational as it should be."[62] Recommendations to improve the program include "Federal agency assignments and responsibilities in range matters need to be more closely defined and clarified, especially on State and private lands with noncommercial forest types. State agency commitment to sound grazing practices in the woodlands must be generated. Funds and personnel knowledgeable about proper livestock grazing in the forest types must be made available to the agencies so the landowner will be assured of sound technical assistance in accordance with his needs."

Significant opportunities for technical assistance to private landowners exist, especially in the West, where Federal, State-owned, and private lands are intermingled, and where policies and practices applied on one ownership may greatly influence the productivity, use, and management of lands of other ownerships. The use of all appropriate educational methods, including demonstration of range management technology, is needed to promote reasonable returns on investments of landowners. Good rangeland management requires cooperation among all rangeland users.

Financing Range Management and Range Development

In addition to additional technical assistance, meeting the demand for range grazing will require considerable investment in range improvements and the maintenance of a higher livestock inventory on farms and ranches. Management and production costs will, therefore, be higher and additional financing will be needed.

[62] U.S. Department of Agriculture, Interagency Work Group, 1974, *op cit.*

A critical factor in the production picture is that grazing systems must be implemented and range improvements must be in place from 5 to 10 years before they will become effective in increasing livestock production. In order to finance needed improvements, the rancher and farmer must have access to financing that can be adjusted to the expected timing of benefits or returns. Some credit agencies do offer long-term, low-interest loans; however, investment capital for range improvements still remains scarce and is often limited to the larger operators with considerable equity.

Research and Technology Transfer

Research Needs

No comprehensive estimate of the total research effort is available. However, in 1975, there were 27 scientist-years (SY) of range research effort expended at State Agricultural Experiment Stations, Forestry Schools, and the Forest Service to meet the needs of the Forest Service.[63,64] An increase of nearly three times, to 75 scientist-years, has been projected for 1985 to meet minimum Forest Service range management technology goals established under the 1975 Resources Planning Act Program for National Forest rangelands and its State and Private Forestry obligations. Substantially more research effort is required to provide the technology needed to meet range management goals of the Bureau of Land Management, other Federal agencies, and the non-Federal landowners.

Range research in recent years has turned from the single purpose range livestock grazing systems approach to the ecosystem approach; that is, research is based on understanding the interrelationships of multiresource productivity and use. Responding to needs of multiple use management, increased effort has also been devoted to the study of interactions and compatibilities of forage production and livestock grazing on wildlife and fisheries habitat, watershed, recreation, and timber supply.

Ecosystem analysis. — Understanding the structure of biological systems and how they function is basic to the wise management of those systems. Intensification of research into the structure and functioning of range ecosystems offers solutions to many concerns such as energy flows, water availability, nutrient cycling through range ecosystems, the interactions among the plants and animals, and their relationship to the physical environment. Such knowledge is needed if the desired output of goods and services will be achieved at a management level that will sustain or enhance the ecosystem structure and function.

Increased concern about preservation of plant and animal species and the use of pesticides focuses attention on the need for improved understanding of ecosystem function. Research is urgently needed to determine habitat requirements and management strategies necessary for preservation and maintenance of endangered species, and to establish guidelines for ecosystem protection and management that will provide the optimum mix of plants and animals.

Range resource inventory. — As of 1979, there was no national system of range resource identification and classification that is consistent among agencies responsible for inventory, administration, research, and providing technical assistance and education concerning the Nation's ranges. Many classification systems are currently in use. The resulting array of systems fosters duplication of effort, but perhaps even more importantly, the inventories and data obtained often are not comparable, seriously restricting their usefulness. Technical research is urgently needed to develop a universally acceptable multiresource identification and classification system.

Resource improvement. — Major gains can be realized from research aimed at better approaches to rehabilitating deteriorated rangelands. Some ranges have been depleted by attempts to cultivate them, by past mismanagement of livestock, by encroachment of undesirable shrubs and trees, and by rodents, insects, and diseases. Past improvement practices generally included mechanical or chemical treatments to control undesirable plant species followed by seeding with desirable forage species. Increased forage production and/or nutritive value was the objective but treatment impacts on other range uses and values were underestimated or undetermined. A more positive ecosystem approach is needed especially with respect to harmful rodents, insects, and diseases. Pest management systems must be developed to regulate the harmful impacts of rodents, insects, and diseases and also to enhance their beneficial impacts.

Restoration of range ecosystems to correspond more closely with their ecological potential should improve stability of all range resource values as well as increase forage supplies. Biological control of insect and disease pests and undesirable plants, prescribed use of fire, and use of grazing livestock to

[63] National program of research for forests and associated rangelands. Prepared by a Joint Task Force of U.S. Department of Agriculture and National Association of State Universities and Land Grant Colleges, 40 p., August, 1978.

[64] The cost of an average SY in 1975 was $70,000. The cost included all technical and clerical support, together with facility, administrative, and other operational costs needed to support one scientist for 1 year.

Deteriorated range can be restored. Research leading to biological controls of undesirable plants and improved varieties of grasses, forbs and shrubs could greatly facilitate restoration efforts.

manipulate range ecosystems for the betterment of associated resources and uses seem to have fewer undesirable side effects than do use of pesticides or herbicides. Further testing is required to determine their effectiveness and application. New germ plasm and improved varieties of grasses, forbs, shrubs, and, in particular, nitrogen-fixing plants could greatly enhance productivity and forage quality characteristics of many ranges.

Many factors contribute to inefficient use of range forage. Prominent among these are climatic fluctuations and their effects on forage quality and quantity, and inefficient digestion by herbivores. When and to what extent forage can be used most efficiently while maintaining ecosystem stability, and what class or mix of herbivores can most effectively convert forage into a desirable commodity need additional testing.

Knowledge gained through basic morphological and physiological studies of plant species is needed to determine how a species and the ecosystem will respond to management alternatives, and to provide guidelines for proper management and effective utilization. Efficiency of animals in converting forage into animal protein needs to be increased. This can be done through additional knowledge of specific food habits and nutritive requirements of herbivores. Improved animal management to include such benefits as control of internal and external parasites,

improved breeds and breeding, and higher birth rates shows promise for improving efficiency of forage conversion but requires further study.

Coordination with other uses. — Range ecosystems are capable of producing a variety of products. Expanded research efforts are needed to improve our knowledge and understanding of multiresource use interactions. Examples include the compatibilities of livestock grazing with goals for water quality, soil stability, water yield, timber supply, recreation, wildlife, and protection and management of fish habitat on mountain meadow and other riparian ecosystems. The impacts and trade-offs among resources must be understood, particularly in arid and semiarid ecosystems. On forested range, the interrelations of forage values and other resources with silvicultural requirements must be fully understood.

Social and economic aspects of resources use. — Research efforts are needed to identify and quantify the managerial alternatives for range grazing in relation to local, regional, and national socioeconomic needs. Only through understanding of resource interactions can guidelines be developed to assure ecosystem integrity and economic feasibility. Facts and analyses necessary for formulation and guidance of range policies and programs are essential to this range assessment. Current and reliable information for local area planning that is capable of aggregation to regional and national levels, is not now available. A social science approach, parallel to the ecosystem concept which is now providing useful biological range information, is urgently needed. Continued emphasis on developing a systems approach to range assessment must link land supply capability and cost with demand in surfacing alternative ways to meet resource goals at the national level.[65]

Much needs to be learned about the use of range along with pasture and crop residues in the production of red meat without dependence upon grain for finishing. Much low-producing cropland could be used to extend the grazing season so that animal gains could be maintained until acceptable meat grades can be produced from grazing roughage alone. This might decrease the expenditure of fossil fuels and provide red meat at a moderate cost so that people of low and medium incomes would be better able to consume meat. The political and economic consequences and constraints for meeting future demands for livestock roughage need evaluation.

There is a special need to integrate biological and socio-economic research efforts related to long- and short-term consequences of climatic extremes. Efforts are needed to devise management strategies that can be responsive to regional fluctuations in forage resources. Skold[66] has suggested that range resource can be viewed as a "renewable flow resource with variable annual supplies." Evaluation is needed of "the costs of permitting deficit supplies of range outputs to occur against the cost of providing adequate range resource development investments to insure that such deficits do not occur." Such deficit costs as forced liquidations of herds, shipping forages to deficit areas, overgrazing of range so that rehabilitation costs are incurred, and forced changes in other land use should be considered. The costs and benefits of supply deficits, as compared to the costs and benefits of adequate supplies in the long run, need analysis. This concept is consistent with the concept of "Resource Reserve,"[67] ". . . a national asset to be maintained in a condition of readiness to support future growth and culture; . . . a source of potential agricultural production, a flexible system that can respond to unforeseeable needs."

[65] Rummell, Robert S. A systems approach to range assessment. Proceedings: Soc. Amer. For. Natl. Conv., Albuquerque, New Mex., p. 120-124, Oct. 2-6, 1977.

Technology Transfer

The agricultural programs of the U.S. Department of Agriculture agencies have received worldwide recognition for the effectiveness of information delivery to landowners. However, the transfer of technology relating to management and development of range resources has suffered by comparison for many reasons.[68] The transfer of technology about ecology, wildlife, and range management has been less effective than in areas dealing with management of croplands.

Transfer of knowledge involves not only the delivery but also the presentation or packaging of information for those who would use or deliver it. This assessment shows that supply of range grazing in the Plains grasslands could be increased by 1.8 times if range condition could be raised to 60 percent of its potential. Much of the knowledge necessary to accomplish this improvement is available and investments needed for fences and water have largely been made in the past. What is needed is a coordinated effort of all Federal and State agencies responsible for extension, technical assistance, and research to improve the packaging and delivery of information to potential users.

[66] Skold, Melvin D. Dynamics in the range livestock economy: An evaluation of the Range Chapter in the 1980 National Assessment. Communication of April 11, 1979.

[67] Lloyd, R. Duane, et al., 1970, *op cit.*

[68] The Renewable Natural Resource Foundation. A review of forest and rangeland research policies in the U.S. September 1977.

Chapter 6. — Timber

This chapter contains information on: (1) Trends in use and prices of timber and timber products with projections of demands and prices to 2030; (2) international trade in timber products and the present and prospective timber situation in the important trading countries; (3) timber industries in the United States; (4) recent changes in the area, ownership, and productivity of domestic timber resources with projections of supplies to 2030; (5) the economic, social, and environmental implications of rising timber prices; and (6) opportunities for increasing and extending timber supplies.

The material presented updates and revises that published in 1977 in "The Nation's Renewable Resources — an Assessment, 1975,"[1] and is based on material prepared for a comprehensive report, "An Analysis of the Timber Situation in the United States, 1952-2030"[2] which is scheduled for publication in 1981. That report contains detailed statistics on the extent, location, ownership, condition, and productivity of the Nation's commercial timberland and timber inventory. The report also contains detailed historical information on production, trade, consumption, and prices of timber products, and projections of timber demands, supplies, and prices to 2030 along with the supporting analyses.

A number of studies were published in the 1970's that are useful references on the timber situation.[3] These publications supplement this summary and the comprehensive Forest Service study in process.

There are substantive differences among these reports in content and objectives, but the major conclusions about the timber outlook are in general agreement. For example, they showed that the Nation's demands for timber products are likely to grow rapidly in the decades ahead. This outlook of rising timber demands is consistent with the trends in recent decades.

The Demand for Timber

Consumption of industrial roundwood products rose from slightly less than 10 billion cubic feet a year in the early 1950's to the 1977 level of about 13 billion cubic feet. Although there were increases in consumption for nearly all timber products, most of the growth was in pulp products and plywood and veneer.

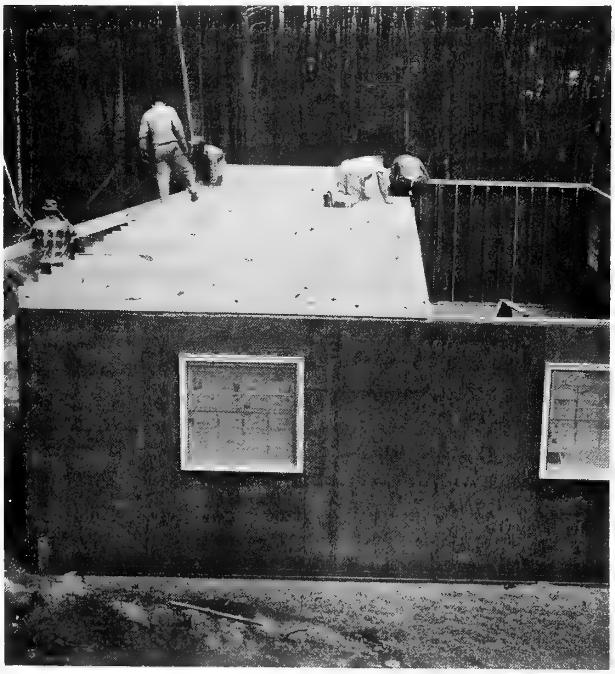
Trends in the Major Timber Product Markets

Future trends in demands for lumber and panel products — plywood, particleboard, hardboard, and insulation board — will be determined in part by trends in the major timber product markets — housing, nonresidential construction, manufacturing, and shipping.

Housing. — In terms of volumes consumed, residential construction has been the most important market for most timber products. In recent years, between one-third and one-half of the softwood lumber and plywood, plus substantial volumes of hardwood plywood, particleboard, and insulation board have been used for the production, upkeep, and improvement of housing.

Housing production in the United States — conventional units and mobile homes — averaged 1.6 million units per year during the 1950's and 1960's, about double the yearly output in the 1920's and 1940's (table 6.1, fig. 6.1). Production moved up again in the early 1970's and averaged 2.1 million units a year from 1970 to 1977.

Timber products, such as lumber and plywood, are basic materials for construction of single-family housing units.



[1] U.S. Department of Agriculture, Forest Service. The Nation's renewable resources — an assessment, 1975. Forest Res. Rep. 21. 243 p. 1977.

[2] U.S. Department of Agriculture, Forest Service. An analysis of the timber situation in the United States, 1952-2030. In process.

[3] President's Advisory Panel on Timber and the Environment. Report of the Panel, 541 p. April 1973.

U.S. Department of Agriculture, Forest Service. The outlook for timber in the United States. Forest Res. Rep. 20., 367 p. 1973.

Cliff, Edward P. Timber: The renewable material. Prepared for the National Committee on Materials Policy, 151 p. August 1973.

Table 6.1 — *Average annual production of new housing units in the United States by type of unit, 1920-1977, with projections to 2030*
(Thousand units)

Period	Total demand	Conventional units			Mobiles		
		Total	One-family	Multifamily	Total	Used as primary residences	Not used as primary residences
1920-29	803	803	527	276	—	—	—
1930-39	365	365	301	64	—	—	—
1940-49	809	780	641	139	29	—	—
1950-59	1,522	1,459	1,208	251	63	41	22
1960-69	1,648	1,443	929	514	205	164	41
1970-79	2,145	1,757	1,102	655	388	310	78
Low projections							
1980-89	2,490	2,160	1,620	540	330	260	70
1990-99	2,080	1,800	1,460	340	280	220	60
2000-09	1,970	1,680	1,260	420	290	230	60
2010-19	2,060	1,770	1,300	470	290	230	60
2020-29	1,720	1,470	1,070	400	250	200	50
Medium projections							
1980-89	2,590	2,250	1,680	570	340	270	70
1990-99	2,240	1,930	1,540	390	310	250	60
2000-09	2,300	1,960	1,410	550	340	270	70
2010-19	2,270	1,930	1,390	540	340	270	70
2020-29	1,980	1,680	1,180	500	300	240	60
High projections							
1980-89	2,700	2,340	1,740	600	360	290	70
1990-99	2,410	2,070	1,610	460	340	270	70
2000-09	2,760	2,350	1,610	740	410	330	80
2010-19	2,550	2,160	1,510	650	390	310	80
2020-29	2,450	2,070	1,370	700	380	300	80

Sources: Housing starts, 1920-49 and 1960-62 — Forest Service estimates derived from data in the following sources: U.S. Department of Commerce, Bureau of the Census. *Housing construction statistics, 1889 to 1964.* 1966, *1950 census of housing.* Vol. I, Pts 2. 1953, U.S. Department of Labor, Bureau of Labor Statistics. *Nonfarm housing starts, 1889-1958.* Bull. 1260, 1959; 1950-59 — U.S. Department of Commerce, Bureau of the Census. *United States census of housing, 1960.* Vol. IV, Pt. 1-A, 1962; 1963-77 — U.S. Department of Commerce, Bureau of the Census. *Housing starts.* Cons. Rep. Ser. C20-78-8. 1978.

Total mobile homes, 1940-49 — Forest Service estimates derived from data in the following sources: U.S. Department of Commerce, Bureau of the Census. *1950 census of housing.* Vol. I, Pt. 1, 1953; 1950-59 — U.S. Department of Commerce, Business and Defense Services Administration. *Construction review.* 7(3). 1961, and Mobile Home/Recreational Dealer Magazine. *Market study, 1967-1968.* 1969; 1960-63 — U.S. Department of Commerce, Business and Defense Services Administration. *Construction review.* 12(8). 1966; 1964-77 — U.S. Department of Commerce, Bureau of the Census, *Housing starts.* Cons. Rep. Ser. C20-78-8. 1978.

Mobiles used as primary residences, Forest Service estimates derived from data in the following source: U.S. Department of Commerce, Bureau of the Census. *United States census of housing, 1960.* Vol. IV, Pt. 1-A. 1962.

Projections: U.S. Department of Agriculture, Forest Service.

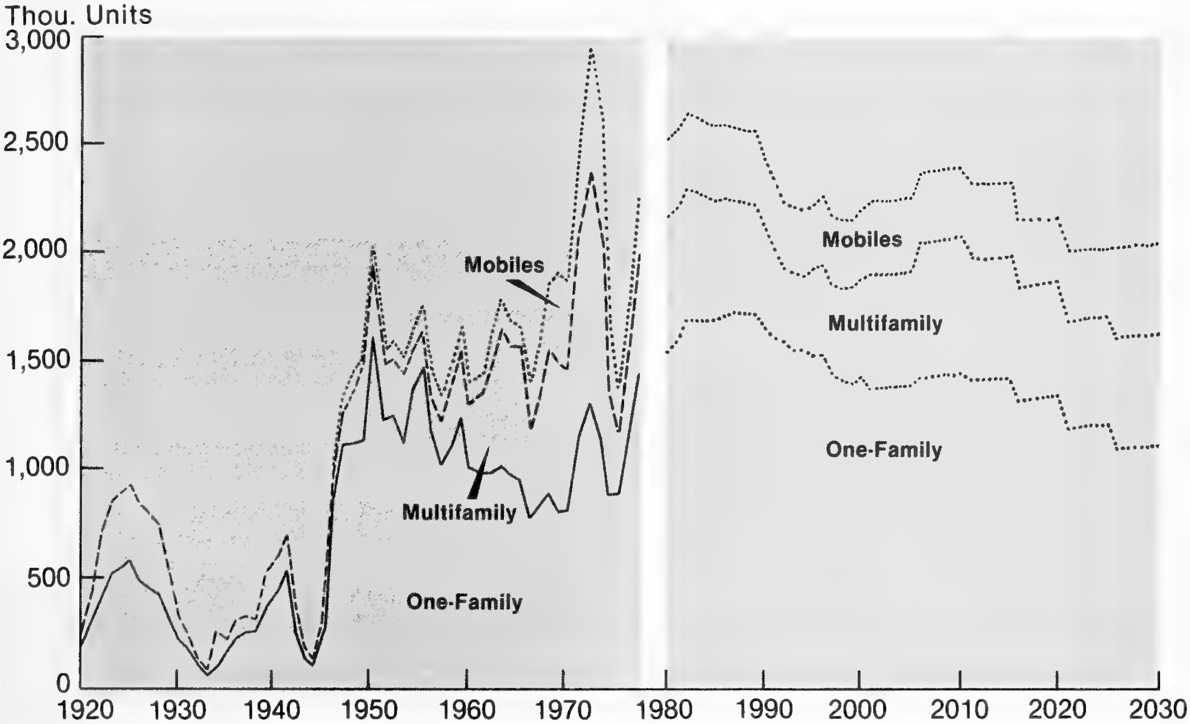
These shifts in housing production reflect changes in demand associated with household formations, the replacement of units lost from the housing stock, and the maintenance of an inventory of vacant units. Analyses of projections of these factors indicate another rise in housing demand in the early 1980's — the medium projection averages nearly 2.6 million housing units annually for the decade. Housing demand drops in the 1990's, a reflection of the decline in birth rates in the late 1960's and early 1970's. After the 1990's, demand will increasingly depend on population growth. As a result, demand is likely to rise in the decade after 2000, then decline slowly through the remainder of projection period.

The type of housing units demanded — single-family, multifamily, mobile homes — is of major importance in projecting demands for timber products because of large differences in average per unit use.

Over the last 50 years, about 70 percent of all housing units produced have been of the single-family type. However, there has been wide variation in the mix of housing types produced. Major booms in the relative importance of multifamily housing occurred in the 1920's and early 1970's. Production reached a peak of over 1 million units in 1972 — about 35 percent of total housing production — before falling to less than 300,000 units in 1975. In the late 1950's, the

Figure 6.1

New Housing Unit Production by Type of Unit, 1920-78, with Projections (Medium Level) to 2030



mobile home emerged as a significant source of new housing units. Its share of total demand grew to over 21 percent in 1972 before dropping to 12 percent in 1977.

Single-family houses are typically occupied by husband-wife households with heads in the middle age classes. Over 85 percent of all such households with heads between ages 35 and 54 lived in single-family housing in 1976. Income also influences housing type. In 1976 nearly 80 percent of all married couples with incomes over $20,000 lived in single-family houses. Occupancy of multifamily units and mobile homes has been the highest among the younger age classes and persons over 65. Households headed by these age classes are generally smaller and are likely to have somewhat smaller incomes.

Because of prospective shifts in the age distribution of the population, and the associated changes in family type and income, the medium projection of demand for single-family units averages nearly 1.7 million units a year in the 1980's (table 6.1, fig. 6.1). In the following decades, there is a slow decline to about 1.2 million units a year in the 2020-2029 decade. Multifamily demand is projected to move up moderately in the early 1980's to 570,000 units a year, about 25 percent of conventional housing production, before declining again in the late 1980's and 1990's. After the mid-1990's, the outlook changes and multifamily units again become more important as the second generation effects of the post-World War II "baby boom" are felt. Demand for mobile units remains relatively constant at 300-340,000 units a year through the projection period. Most of these units will be produced for primary residential use and are expected to become larger and more houselike.

In addition to the timber products consumed in production of new residential units, substantial volumes are used annually for the upkeep and improvement of existing units. Between 1960 and 1977, the years for which reliable data are available, expenditures for upkeep and improvements increased moderately from about $15 billion to $20 billion (1972 dollars). For the purposes of this study, it was assumed that expenditures would grow in the projection period at about the same rate as the housing inventory. Under this assumption, the medium pro-

jection of annual expenditures rises to about $36 billion in 2030. This results in a small increase in average annual expenditures per household.

New nonresidential construction. — About 10 percent of the lumber, plywood, and building board used each year goes into new nonresidential construction. This diverse market includes: (1) Commercial buildings (private offices, stores, warehouses, garages, and restaurants); (2) other buildings (industrial, religious, educational, hospital, and institutional buildings); (3) public utilities (including sewer and water systems); (4) highways; and (5) all other (military, conservation, and development projects, and construction not included in other categories). The only common unit for such a heterogeneous group is expenditures measuring the dollar value of construction put in place.

Expenditures for the various classes of construction have fluctuated rather widely in response to changing economic conditions. However, the long-run trend for all types combined has been strongly upward, reaching a level near $75 billion (1972 dollars) in the late 1960's and early 1970's. There has been a fairly close relationship between changes in expenditures for the major classes of nonresidential constructions and changes in the gross national product. Projections based on these relationships and the assumed growth in gross national product show substantial increases for each class of construction between 1976 and 2030, ranging from around 2.1 times for highways to around 3.9 times for commercial buildings.

Total projected expenditures for new nonresidential construction rise from late 1960's/early 1970's level of around $75 billion (1972 dollars) to $165.7 billion in 2030 (medium projection). The rates of growth underlying this projection decline throughout the projection period. There is also a decline in new nonresidential construction expenditures as a percentage of gross national product. This is consistent with trends since the late 1960's and with estimates that the service industries will account for a growing share of the Nation's gross national product in the future.

Manufacturing. — Almost a tenth of the lumber, veneer, and plywood and nearly 40 percent of the hardboard and particleboard consumed in the United States in 1976 was used in the manufacture of a wide range of products such as household furniture, consumer goods, and commercial and industrial equipment.

Shipments of manufactured products increased substantially between 1948 and 1976. During this period there was close correlation between changes in the value of shipments of certain groups of products and changes in gross national product and other measures of economic growth.

Projections to 2030 based on these past relations, and the assumed growth in economic activity and income, range from over a threefold increase for commercial and institutional furniture to a rise of about 2.3 times for products other than furniture. As in the case of nonresidential construction, the rates of increase in value of shipments for all groups of products, including household furniture, drop significantly over the projection period.

Shipping. — In 1976, about 16 percent of the lumber and 4 percent of the plywood consumed was used in the production of wood pallets, container manufacture, and for dunnage, blocking, and bracing. More than 70 percent of the lumber and over one-half of the plywood consumed in shipping was used for pallets.

In the 1950's, 1960's, and the first half of the 1970's, pallet production rose rapidly as new methods of materials handling were introduced and as facilities

Timber products are used in a wide range of manufactured goods such as furniture, sporting goods, boats and signs and displays.

geared to the use of pallets were constructed. During this period pallet output and manufacturing production were closely correlated. Projections based on this relationship, and assumed growth in the value of manufacturing shipments as the gross national product rises, indicate continuing large demand for pallets. The medium projection increases to 600 million pallets by 2030, about triple 1976 production.

Although the increase in terms of numbers of pallets is large, the rates of growth drop rapidly from an average of 7.3 percent in the 1960's to 2.0 percent in the 1990's and 1.1 percent in the decade before 2030. Pallet output per dollar of manufacturing shipments rises slowly to about the year 2000 and subsequently declines. Such a falloff means that growth in pallet demand for use in new materials handling systems gradually ends, and that expansion thereafter depends to a large degree on growth in industrial and agricultural production.

Markets for wood containers showed modest growth in the 1960's. However, they declined in the 1970's in response to displacement by fiber and plastic containers, metal and fiber barrels and pails, and multiwall bags. Based on past relations and anticipated trends in manufacturing and agricultural production, continued modest declines have been projected.

In the past three decades, use of lumber for dunnage, blocking, and bracing in railroad cars, trucks, and ships has increased about 0.5 percent per year to an estimated 860 million board feet. This relatively modest growth, in a period of rapid increases in shipment of goods of all kinds, apparently reflects rising use of palletized, containerized, and bulk shipment systems. Growth in such systems is expected to continue. Consequently, demand for lumber for dunnage, blocking, and bracing has been projected to continue to rise during the projection period, but only at a rate of about 0.2 percent per year.

Trends in Unit Use

The projected level of activity in the major markets discussed above is only one of the determinants of future demands for lumber, plywood, and other panel products. Also important are changes in unit use, i.e., the volume of product used per dwelling unit, per pallet, per dollar of expenditure, or other measure of market activity.

Changes in timber product prices relative to the general price level and to competing materials have had important impacts on unit use. In projecting future trends, changes in the prices of timber products relative to the general price level from the 1950's through the early 1970's — the period during which the basic data on unit use were collected[4] — were assumed to continue through the projection period:

Product	*Assumed annual rate of change in relative prices — base level projections*
Lumber	
Softwood	0.7
Hardwood	0.7
Plywood	
Softwood	0.0
Hardwood	0.0
Paper and board	0.0

Only lumber prices increased in the base period. There were no clearly defined upward or downward trends for most other products and it was assumed that the relative prices would remain constant until 2030.

These expectations on future prices will be realized only if the supplies of timber (stumpage) are adequate to meet the projected demands for timber products. The base level projections of timber supplies presented in a following section indicate that if timber owners continue to respond to stumpage price and inventory changes and manage their timberlands much as they have in the recent past, timber supplies will not be large enough to meet the projected demands and especially for softwood sawtimber products. Thus, unless action is taken to raise timber growth and improve timber utilization, the increase in timber product prices will be higher than assumed and the associated projections of demands lower.

In response to the varying rates of price change and other forces, there have been widely divergent trends in unit use of the major timber products in the last two decades. The unit use of lumber has declined in most end uses, especially in those, such as housing, where there has been extensive displacement by panel products. In contrast, plywood, hardboard, and particleboard consumption per unit has been rising in most end uses.

[4] The trends shown by these data reflect the effects of price changes in the period in which they were collected. A projection of these "base level" trends assumes a continuation of similar price changes in the future. Prices are measured in constant 1967 dollars and are net of inflation or deflation.

Demand for lumber is projected to grow rapidly in the 1980's, largely in response to rising demands for new housing and pallets.

In general, it has been assumed that recent trends in unit use would continue. For some end use markets, however, such trends have been modified by a judgment evaluation of the various factors likely to affect future changes. For example, the rate of decline in the unit use of lumber in housing in the 1940's and 1960's has been sharply reduced because nearly all of the potential displacement by panel products has already taken place. As another illustration, the expected increases in the cost of fossil fuels, and the associated increases in the costs of many materials which compete with wood, such as steel, plastics, and aluminum, have been taken into account. Such increases generally improve the cost position of wood relative to competing materials, and result in higher levels of per unit use of wood products.

Projected Demand for Lumber and Panel Products

Based on the projections and assumptions discussed, demands for lumber and panel products are projected to rise substantially in the next 50 years in all the major end use areas (tables 6.2, 6.3, and 6.4). In terms of volume, the largest increase for lumber is in shipping, and for plywood in nonresidential construction. The largest increase for the other panel products — insulation board, hardboard, and particleboard — is in manufacturing.

In addition to the major end uses discussed above, an estimated 4.8 billion board feet of lumber, 4.9 billion square feet (3/8-inch basis) of plywood, and 3.2 billion square feet (3/8-inch basis) of other wood-based panel products were used in 1976 for other purposes. These included upkeep and improvement of nonresidential structures; roof supports and other construction in mines; made-at-home products such as furniture, boats, and picnic tables; and made-on-the-job products such as advertising and display structures.

There are no historical data on the consumption of timber products in these various uses. Accordingly, use for these purposes in 1962, 1970, and 1976 was estimated by subtracting volumes of timber products consumed in the specific end uses discussed above from the estimated total consumption of each product. These residuals probably include some lumber, plywood, and other panel products which properly belong in the construction, manufacturing, or shipping sectors. The "other use" categories also include any statistical discrepancies associated with the estimates of production, imports, and exports used in estimating total consumption.

Because of the lack of a statistical base for projecting these residuals, it was assumed that use for these purposes would rise in line with projected demands in the other markets, except new housing. New housing was excluded because its demand is so strongly influenced by the age distribution of the population.

Lumber. — Lumber consumption in all uses in 1976 was 42.7 billion board feet, a volume about 10 percent above the average of the 1950's and 1960's. Projected demand for lumber with base level price trends shows a rather steep rise to a 1990 level of 58.0 billion board feet (table 6.2). This growth is attributable largely to the rise in demands for new housing and for pallets. After 1990, and primarily because of the leveling off and subsequent decline in housing, projected demand increases more slowly to 67.3 billion board feet in 2030.

In recent decades, softwood species have composed around four-fifths of the lumber consumed. However, over the projection period, an increase in the proportion of hardwoods is expected because of the more rapid relative growth in uses such as shipping (pallets), manufacturing, and nonresidential construction (railroad ties) where hardwoods are predominant.

The alternative assumptions on population and economic growth discussed in the assumptions chapter have substantial impacts on the demand for lumber in all end uses (table 6.2). In 2030, projected total demand at base level price trends ranges from 59.8 billion board feet for the low projection to 77.8 billion board feet for the high projection.

Plywood. — Plywood consumption in 1976 was 20.8 billion square feet (3/8-inch basis) — more than twice the volume consumed in 1960 and about five times that of 1950. With base level price trends, the medium projection of demand rises to 34.1 billion square feet in 2030 (table 6.3). This projection is about double average consumption in the early 1970's. As in the case of lumber, the differing assumptions on growth in population and economic activity have substantial impacts on demand, inducing a range of about 9 billion square feet between the high and low projections.

Since the late 1950's, softwood plywood has comprised about four-fifths of the total plywood consumption. Analysis of prospective growth in demand by major uses indicates that this percentage is likely to remain about the same through the projection period.

Board. — Board consumption, including insulation board, hardboard, and particleboard, reached 13.5 billion square feet (3/8-inch basis) in 1976 — about four times the volume consumed in 1950. Particleboard (including medium-density fiberboards) accounted for much of the increase, with consumption rising from less than 50 million square feet in 1950 to 6.9 billion in 1976. Hardboard use increased fivefold. Although consumption of insulation board has not shown comparable growth, this product still accounted for a third of the board consumed in 1976.

Projections of demand for board at base level price trends reaches 37.3 billion square feet (medium level) by 2030 — 2.8 times the volume consumed in 1976 (table 6.4). Particleboard and hardboard are expected to continue to show the largest increases. Much of the particleboard growth is expected to be in structural panels. Under the alternative assumptions on growth in population and economic activity, projected total demands in 2030 range from about 32.3 to 43.2 billion square feet.

Projected Demand for Pulpwood

Since 1920, pulpwood consumption in U.S. mills has increased more than 12 times, rising from 6.1 million cords to 77.6 million cords[5] in 1977. As a result of this growth and an increase in export demand, about one-third of the timber harvested from domestic forests is used as pulpwood.

[5] This included 45.7 million cords of roundwood and 31.8 million cords of chips and sawdust obtained from slabs, edgings, veneer cores, and other byproducts of primary manufacturing plants.

Table 6.2 — *Lumber consumption in the United States, by species group and major end use 1962, 1970, and 1976, with projections (base level) to 2030*

Year	Total	Per capita average	By species group: Softwoods	By species group: Hardwoods	By end use: New housing	Residential upkeep and improvements	New non-residential construction[1]	Man-facturing	Shipping	All other uses[2]
	Million board feet	*Board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*	*Million board feet*
1962	37,300	200	30,800	6,500	13,940	4,400	4,200	4,240	4,340	6,180
1970	39,500	193	32,100	7,300	12,270	4,690	4,700	4,670	5,720	7,450
1976	42,700	199	36,200	6,500	16,555	5,690	4,470	4,300	6,900	4,785
Low projections[3]										
1990	55,210	234	45,540	9,670	22,160	7,110	5,590	5,270	9,030	6,050
2000	55,110	224	44,610	10,500	18,970	7,680	5,910	5,640	10,300	6,610
2010	59,440	237	47,680	11,760	20,170	8,140	6,240	6,050	11,650	7,190
2020	61,490	243	48,360	13,130	19,920	8,570	6,540	6,160	12,690	7,610
2030	59,780	240	45,790	13,990	15,945	8,730	6,900	6,420	13,760	8,025
Medium projections[3]										
1990	57,950	238	47,830	10,120	23,700	7,160	5,870	5,530	9,420	6,270
2000	59,880	230	48,590	11,290	21,665	7,790	6,320	6,130	10,980	6,995
2010	65,310	237	52,430	12,880	23,010	8,390	6,810	6,790	12,570	7,740
2020	66,590	230	51,970	14,620	21,050	8,850	7,290	7,220	13,850	8,330
2030	67,270	224	51,290	15,980	18,305	9,080	7,850	7,900	15,180	8,955
High projections[3]										
1990	60,550	238	49,990	10,560	25,105	7,210	6,160	5,780	9,810	6,485
2000	64,370	228	52,320	12,050	24,130	7,900	6,760	6,610	11,610	7,360
2010	72,600	230	58,600	14,000	27,190	8,730	7,430	7,500	13,440	8,310
2020	72,660	205	56,600	16,060	23,060	9,260	8,120	8,210	14,930	9,080
2030	77,830	198	59,940	17,890	23,660	9,680	8,920	9,210	16,450	9,910

[1] In addition to new construction, includes railroad ties laid as replacements in existing track.

[2] Includes upkeep and improvement of nonresidential buildings and structures; made-at-home projects, such as furniture, boats, and picnic tables; made-on-the-job items, such as advertising and display structures; and a wide variety of miscellaneous products and uses.

[3] Projections based on alternate assumptions about growth in population and economic activity as specified in the section on basic assumptions.

Note: Data may not add to totals due to rounding.

Source: Data for 1962, 1970 and 1976 based on information published by U.S. Departments of Agriculture and Commerce.

Projections: U.S. Department of Agriculture, Forest Service.

Demand for pulpwood is a derived demand in the sense that it is determined by demands for paper, board, and other pulp products. Consumption of paper and board has risen from about 8 million tons in 1920 to 66.2 million tons in 1977. Per capita consumption has also increased rapidly from 145 to 611 pounds.

Consumption of most major grades of paper and board has increased substantially in recent years. However, there have been large differences in the rates of growth. These have resulted from such factors as changes in consumer tastes, development of new pulp-based products, inroads of substitutes, and varying rates of growth in major sectors of the economy. In partial recognition of these differences, the various types and grades of paper and board have been grouped into three categories — paper, paperboard, and building board (insulation board and hardboard) — that have a common relation to one or more of the determinants of demand such as economic activity or income.

Most paper is consumed in one form or another by individuals, with the level of use being a function of income. Consequently, there has been a close statistical relation between changes in per capita consumption of paper and changes in per capita disposable personal income. On the other hand, for paperboard, which is used primarily for packaging industrial and agricultural commodities, per capita consumption has shown a closer relation to changes in the per capita gross national product. Most of the growth in the consumption of building board, which is used in construction for such purposes as sheathing and underlayment and in manufacturing, has been associated with changes in those sectors of the economy.

Table 6.3 — *Plywood consumption in the United States, by species group and major end use, 1962, 1970, and 1976, with projections (base level) to 2030*

(3/8-inch basis)

Year	Total	Per capita average	By species group: Softwoods	By species group: Hardwoods	By end use: New housing	Residential upkeep and improvements	New non-residential construction	Manu-facturing	Shipping	All other uses[1]
	Million square feet	*Square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*
1962	11,716	63	9,311	2,404	4,180	1,030	1,690	1,870	[2]	2,946
1970	17,822	87	14,038	3,784	6,330	2,510	1,939	1,656	591	4,796
1976	20,716	96	17,135	3,581	8,410	3,350	1,875	1,550	738	4,793
					Low projections[3]					
1990	27,800	118	22,670	5,130	11,190	4,160	3,130	1,750	1,100	6,470
2000	27,850	113	22,450	5,400	9,420	4,490	3,660	1,870	1,230	7,175
2010	30,050	120	24,260	5,790	10,005	4,760	4,210	1,900	1,370	7,805
2020	31,390	124	25,330	6,060	9,850	5,080	4,620	1,970	1,480	8,390
2030	30,490	122	24,410	6,080	7,885	5,240	5,020	1,930	1,610	8,805
					Medium projections[3]					
1990	29,000	119	23,670	5,330	11,970	4,190	3,230	1,840	1,140	6,630
2000	30,050	115	24,280	5,770	10,785	4,550	3,860	2,040	1,310	7,505
2010	32,840	119	26,590	6,250	11,430	4,900	4,540	2,150	1,480	8,340
2020	33,830	117	27,220	6,610	10,420	5,240	5,100	2,330	1,620	9,120
2030	34,130	114	27,290	6,840	9,070	5,450	5,680	2,400	1,770	9,760
					High projections[3]					
1990	30,170	118	24,640	5,530	12,680	4,220	3,330	1,920	1,210	6,810
2000	32,140	114	26,010	6,130	12,025	4,620	4,070	2,200	1,390	7,835
2010	36,390	115	29,510	6,880	13,525	5,100	4,900	2,370	1,590	8,905
2020	36,890	104	29,670	7,220	11,420	5,480	5,660	2,660	1,750	9,920
2030	39,540	101	31,770	7,770	11,755	5,810	6,440	2,800	1,920	10,815

[1] Includes upkeep and improvement of nonresidential buildings and structures; mining; made-at-home projects, such as furniture and boats; made-on-the-job items, such as advertising and display structures; and a wide variety of other miscellaneous products and uses. Also includes shipping in 1962.

[2] Included in all other uses.

[3] Projections based on alternate assumptions about growth in population and economic activity as specified in the section on basic assumptions.

Note: Estimates for manufacturing, shipping, and all other uses include veneer.

Sources: Data for 1962, 1970 and 1976 based on information published by U.S. Departments of Agriculture and Commerce.

Projections: U.S. Department of Agriculture, Forest Service.

On the basis of past relations and trends, total demand for paper, paperboard, and building board at base level price trends is projected to rise to 123.4 million tons (medium level) in 2000, and to 194.4 million tons in 2030—some three times 1976 consumption. Projections of per capita demand also rise, reaching 948 pounds in 2000 and 1,296 pounds in 2030, although the rates of growth drop throughout the projection period.

Effects of the alternative assumptions on growth in population and gross national product are substantial, with projected total demand for paper and board ranging from a low of 157.0 to a high of 251.5 million tons in 2030.

In addition to changes in demand for paper and board, the amounts and kinds of fibrous materials used in its manufacture will strongly influence future demand for pulpwood. Since the 1920's, average use of fibrous material per ton of production (all grades of paper and board combined) has shown little variation, ranging from 0.992 to 1.092 tons.

Although there has not been much change in the amount of fibrous materials used per ton of paper and board produced, there have been changes in the mix of fibers consumed. For example, since 1950 new woodpulp has risen from roughly two-thirds to around four-fifths of the total fibrous mix. Use of wastepaper, on the other hand, declined from around a third of the total fibers used in 1950 to around 19 percent in 1977. Use of other fibers dropped from about 5 percent to less than 2 percent.

Table 6.4 — *Board consumption in the United States, by type of board and major end use, 1962, 1970, and 1976, with projections (base level) to 2030*

(3/8-inch basis)

Year	Total	Per capita average	By type of board			By end use				
			Insulating board	Hardboard	Particle-board	New housing	Residential upkeep and improvements	New non-residential construction	Manu-facturing	All other uses[1]
	Million square feet	*Square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*	*Million square feet*
1962	5,590	30	3,844	930	816	2,213	[2]	[2]	[2]	[2]
1970	9,608	47	4,552	1,541	3,515	2,760	1,415	1,050	1,790	2,593
1976	13,497	63	4,479	2,146	6,872	3,540	2,160	1,095	3,480	3,222
					Low projections[3]					
1990	22,810	97	4,720	3,490	14,600	6,590	3,510	2,150	5,310	5,250
2000	25,260	103	4,420	4,130	16,710	6,235	4,050	2,750	6,070	6,155
2010	29,000	116	4,690	5,020	19,290	6,895	4,800	3,350	6,805	7,150
2020	31,380	124	4,580	5,550	21,250	7,080	5,370	3,800	7,265	7,865
2030	32,290	130	4,270	5,610	22,410	5,745	6,050	4,210	7,695	8,590
					Medium projections[3]					
1990	23,820	98	4,920	3,650	15,250	7,000	3,530	2,230	5,620	5,440
2000	27,300	105	4,770	4,490	18,040	7,045	4,120	2,920	6,660	6,555
2010	31,950	116	5,120	5,540	21,290	7,805	4,950	3,650	7,730	7,815
2020	34,670	120	4,900	6,090	23,680	7,455	5,550	4,250	8,610	8,805
2030	37,320	124	5,100	6,480	25,740	6,540	6,290	4,840	9,690	9,960
					High projections[3]					
1990	24,790	97	5,120	3,780	15,890	7,410	3,560	2,310	5,890	5,620
2000	29,200	103	5,110	4,820	19,270	7,810	4,170	3,110	7,190	6,920
2010	35,400	112	5,710	6,200	23,490	9,190	5,150	3,990	8,590	8,480
2020	38,390	108	5,370	6,920	26,100	8,155	5,810	4,790	9,850	9,785
2030	43,250	110	5,540	7,570	30,140	8,385	6,710	5,560	11,310	11,285

[1] Includes upkeep and improvement of nonresidential buildings and structures; shipping; mining, made-at-home projects, such as furniture; made-on-the-job items, such as advertising and display structures; and a wide variety of other miscellaneous products and uses.

[2] Not available.

[3] Projections based on alternate assumptions about growth in population and economic activity as specified in the section on basic assumptions.

Sources: Data for 1962, 1970 and 1976 based on information published by U.S. Departments of Agriculture and Commerce, and the National Particleboard Association.

Projections: U.S. Department of Agriculture, Forest Service.

In recent years, a number of things have developed — concern about the environment, problems of solid waste disposal, and increasing competition for timber — that point to the likelihood of future growth in wastepaper recycling. Use of recycled fibers per ton of paper and board produced has been assumed to rise from 0.20 ton in 1977 to 0.28 ton by 2000 and to 0.32 ton by 2030. The latter level is about 20 percent below the current rates in Japan and the Netherlands, and somewhat under the rate achieved for a time in the United States during World War II. Projected use of new woodpulp drops from 0.81 ton in 1977 to 0.70 ton in 2030. Use of other fibrous materials per ton is expected to show little change.

Despite the decline in use per ton, demand for woodpulp for the manufacture of paper and board rises rapidly through the projection period from about 50 million tons in 1977 to 131.5 million in 2030. Demand for woodpulp for the manufacture of rayon, plastics, and other nonpaper products, which has declined somewhat in the recent years, is expected to stabilize at about 1 million tons.

Because of offsetting trends resulting from changes in pulping technology, grades of paper produced, and species of wood used, average consumption of pulpwood per ton of pulp produced has not changed significantly in the past 50 years. It has been assumed that the net effects of continuing technological developments and further increases in use of high-yield hardwoods will cause a decline in consumption of pulpwood per ton of pulp produced, from an average of about 1.6 cords in the mid-1970's to 1.4 cords by 2030.

Given the above projections and assumptions, the demand for pulpwood in U.S. mills rises to 128 million cords in 2000 with a further increase to 178 million in 2030. These volumes are, respectively, 1.6 times and 2.3 times the 77.6 million cords consumed in 1977. As indicated in the tabulation below, the alternative assumptions on growth in population and economic activity have large impacts on pulpwood demand in the decades beyond 1980.

Year	*Total pulpwood demand in U.S. mills (Million cords)*		
1977		77.6	
	Low projections	*Medium projections*	*High projections*
2000	116.1	127.7	141.2
2030	141.7	178.4	234.0

The demand for pulpwood more than doubles by 2030 — most of the increased demand will fall on domestic forests.

Part of the demand for pulpwood has been met by the use of slabs, edgings, veneer cores, sawdust, and other byproducts produced at primary manufacturing plants. Between 1950 and 1977, use of these materials increased from 1.2 million cords to 31.8 million cords. Most of the economically available supplies of such material are currently being utilized, either for pulp production, fuel, particleboard manufacture, or for export. Competition for the available supplies of byproducts is likely to intensify. As a result of this and the projected slow growth in domestic lumber production, followed by a decline toward the end of the projection period, the volume of byproducts used for pulpwood is expected to show little change from current levels. However, as a proportion of total pulpwood use, residues decline from 41 percent in 1977 to 25 percent in 2000 with a further drop to 19 percent by 2030.

Projected Demand for Other Industrial Timber Products

As shown in the following tabulation, a variety of other industrial roundwood products is consumed in the United States.

Product	*Standard unit of measure*	*1952*	*1962*	*1970*	*1976*
Cooperage	Million board feet	355.3	216.0	214.7	93.9
Piling	Million linear feet	41.2	41.5	28.8	39.4
Poles	Million pieces	6.5	6.7	5.4	6.3
Posts	Million pieces	306.0	168.7	97.7	59.9
Mine timbers	Million cubic feet	81.0	48.4	32.1	23.6
Other[6]	Million cubic feet	235.2	157.6	198.8	178.9
Total other industrial	Million cubic feet	698.8	465.4	424.0	378.8

Total consumption of these products amounted to 379 million cubic feet in 1976. This was somewhat

[6] Includes charcoal wood, roundwood used in the manufacture of particleboard; poles and rails used in fencing; bolts used for products such as shingles, wood turnings, and handles, and other miscellaneous items such as hop poles and the wood used for the production of chemicals.

below the general level of the 1960's when estimated consumption averaged about 500 million cubic feet per year, and far below consumption of more than 2 billion cubic feet annually in the early 1900's.

The downward trend in consumption of miscellaneous industrial roundwood products which began around 1910 appears to have bottomed out in recent years. For this report, it was assumed that demand for these products will rise slowly to 900 million cubic feet by 2010 and remain at that level through 2030. Individual products are likely to show divergent trends as in the past. Much of the increase is expected to come from expanding use of roundwood for structural grades of particleboard. There also may be a significant increase in use for chemicals including the production of methanol for fuel. However, at this time, with the existing technology and the current costs of petroleum and chemicals produced from other materials, the economic potential is quite limited.

In addition to the roundwood, some 516 million cubic feet of plant byproducts such as sawdust, slabs, and edgings were used in the production of charcoal, chemicals, and various other goods in 1976. Because of the competition from other uses and limitations on supply, little change is expected in the future.

Fuelwood

Fuelwood consumption in 1976 was an estimated 18 million cords or 1.4 billion cubic feet. This included approximately 330 million cubic feet of roundwood from growing stock trees and 270 million cubic feet of primary plant byproducts. This volume was equivalent to about 21 million tons of dry wood. Additionally, some 10 million tons (dry basis) of bark was consumed for fuel in 1976.

Fuelwood cut from roundwood was used almost entirely for domestic heating and cooking. Plant byproducts were used both for domestic purposes and for industrial fuel, primarily at wood processing plants.

Residential use of fuelwood. — Roundwood was the major source of energy for the United States until the 1880's. Fuelwood use dropped sharply in the first half of the present century, replaced by fossil fuels and electricity. Difficulties in fossil fuel supply during World War I, The Great Depression, and World War II brought renewed interest in wood, but these episodes did not significantly change the rapid decline in fuelwood consumption. By 1970, less than 2 percent of all households in the United States used wood as their primary fuel for heating and less than 1 percent as their primary cooking fuel.

The use of wood for domestic heating has been rising since 1973 in response to rapid increases in the costs of other fuels.

With the unprecedented rise in fossil fuel prices which has occurred since 1973, an increasing number of households (estimated at 912,000 in 1976) is using wood as a primary source of heating.[7] A much greater number is using wood for supplementary heat or for esthetic purposes. In 1976, 58 percent of all new single-family homes built had one or more fireplaces, as compared to 44 percent in 1969.[8] Scattered data indicate that the number of wood stoves, not included in the figure for fireplaces, has also risen substantially. Thus, it is assumed for this Assessment that residential use of wood fuels, especially from roundwood, will increase steadily from 6 million cords in 1976 to approximately 26 million cords in 2030. However, it is conceivable that major alternative sources of oil, such as tar sands and oil shale, and natural gas from geopressurized hot fluids, may become sufficiently developed before then to reverse this trend.

Industrial and commercial uses of fuelwood. — Of the nearly 800 million cubic feet (11 million tons, dry basis) of wood byproducts used as fuel in 1976, about 90 percent went to produce steam heat and electricity at wood processing plants. Additionally, pulpmills used about 5 million tons, dry basis, of bark removed from roundwood pulpwood and 61 million tons of spent liquid solids for fuel.[9] Wood processing plants in the future are likely to use as fuel nearly all their

[7] U.S. Department of Commerce, Bureau of Census. Residential energy uses. Series H-123-77. 8 p. May 1978.

[8] U.S. Department of Commerce, Bureau of Census. Current housing reports. Series H-150-76, General housing characteristics for the United States and Regions, 1976; Annual Housing Survey-1976, part A. 1978.

[9] American Paper Institute, Raw Materials and Energy Division, U.S. pulp, paper and paperboard industry: estimated fuel and energy use, 1 p. April 10, 1978.

bark and most of their wood byproducts not sold for woodpulp or particleboard furnish.[10] As fossil fuel prices continue rising, some plants will bring in nearby forest residues, or urban residues, to supplement mill fuels.

Currently, a small amount of mill wood byproducts and bark is used for producing heat or steam power at other manufacturing plants or institutional commercial buildings outside the wood processing industries. There is much interest in the possibility of increasing the use of wood for such purposes—especially as an outlet for forest residues and wood from cull trees, thinnings, and dead trees.[11] It is too early to predict with any reliability the eventual extent of such use.

In 1978, wood and bark provided all or part of the fuel requirements of some 10 or 12 utility plants in the United States.[12] In at least one case, excess power produced at a pulpmill was used as part of a municipal electricity supply. More such arrangements are expected.[13] Plans for several new wood-using steam-electric plants have been announced. For example, by 1978, Vermont's Burlington Electric had converted one coal furnace to accept wood chips. The company converted another in 1979 and plans to construct a new 50 megawatt plant by 1983. Nearly all wood used in steam-electric facilities in the past has been mill byproducts, but harvesting of timber specifically for fuel is envisioned in some current plans.[14,15] With increasing use of sawmill and veneer mill byproducts for pulp and particleboard furnish, or for fuels by wood-processing plants themselves, there probably will be few locations in the United States where sufficiently large concentrations of mill residues will be available for utility operation. A recent study indicated that a 50 megawatt steam-electric plant would require 240,000 dry tons of wood annually.[16]

[10] Jamison, R. L., N. E. Methuen, and R. A. Shade. Energy from biomass. A report of Task Force No. 5 of the Industrial Energy Group; National Association of Manufacturers, Washington, D.C. 15 p. June 29, 1978.

[11] U.S. Department of Energy, Solar energy—a status report. 55 p. June 1978.

[12] U.S. Department of Energy, Federal Energy Regulatory Commission, Monthly power plant reports (F.E.R.C. Form No. 4) Computer printout dated April 3, 1979.

[13] U.S. Department of Agriculture, Forest Service. Quads. Report No. 7 on energy activities. August 1979.

[14] See, for example, New England Energy Congress. Final report, May 1979; sponsored by the New England Congressional Caucus and Tufts University. 454 p. (Available from the New England Energy Congress, 14 Whitfield Road, Somerville, Maine 02144.)

[15] See also, State of Washington, Department of Natural Resources. Wood waste for energy study. Report to State of Washington, House of Representatives, Committee on Natural Resources. 216 p. 1978.

The ultimate magnitude of fuelwood use by steam-electric plants will depend on many factors, such as price trends for coal and oil in comparison to fuelwood, practical aspects of developing assured long-term fuelwood supplies, problems in collecting and storing very large quantities of wood or bark, and advantages or disadvantages of the various fuels in meeting emission control standards.[17] The National Energy Act of 1978 provides for incentives toward cogeneration and use of fuels other than oil and gas in steam-electric facilities.[18] Because the fuelwood requirements of even small steam electric plants would be very large, the potential impact of a single such installation on local timber supply could be great. If many were developed, there would be major impacts on timber resources, and especially hardwood resources, over large areas. Again, however, it is too early to make reliable projections of timber demand for steam-electric utilities.

Plantations.— With practices similar to those used in modern agriculture, intensively cultivated plantations of fast-growing trees can produce as much as 10 tons per acre (dry basis) per year of wood, bark, and foliage. The possibility of establishing such plantations on a vast scale to provide a steady source of fuel for steam-electric utilities, or raw material for chemical conversion to liquid fuels, recently has received much attention from scientists and energy policy-makers.[19, 20] Plantations of tens of thousands or hundreds of thousands of acres might be required. Several small-scale (1,000 acre) trials now are planned to provide improved estimates of yields and costs of such plantations. Large-scale application could profoundly affect forestry in the United States; but until more information on practical economics becomes available, it is not possible to make meaningful projections of timber demand and supply effects.

Environmental and economic considerations.— Fuel uses already provide outlets for large quantities of mill byproducts and for some urban wood refuse, thus mitigating large waste-disposal problems. Producing fuel from logging residues, cull trees, and portions of overstocked stands would, in many cases,

[16] Letter from R. L. Jamison, Director of Energy Management, Weyerhaeuser Company, to Richard Bryant, U.S. Department of Agriculture, Forest Service, April 10, 1978.

[17] Ellis, Thomas H. Should wood be a source of commercial power? Forest Products J. 25(10): 12-16. October 1975.

[18] U.S. Department of Energy, Office of Public Affairs. The National Energy Act. DOE information kit. 47 p. November 1978.

[19] See for example: Inman, R. E. Silvicultural biomass farms, MITRE Corp., McLean, Virginia Vol. I summary. 62 p. 1977.

[20] See also: Calef, Charles E. Not out of the woods. Environment 18(7): 17-25. September 1976.

reduce fire hazards and improve the economic feasibility of intensive silviculture. However, there could be serious environmental and economic problems associated with large-scale developments such as steam-electric utility plants.[21] One potential result could be increasing competition for residuals currently used in manufacture of woodpulp and particleboard. Another possibility is esthetic and physical deterioration of forest sites. This problem may become a social issue, particularly in areas where timber harvesting has been unobtrusive heretofore. It appears likely, therefore, that the potential impacts of major fuelwood-consuming installations will have to be evaluated carefully. And, the costs of delivering a sustained, long-term wood supply to expensive installations requiring hundreds of thousands of tons of fuel must be weighed with equal care — case-by-case.

Projected Demand for Timber

The projections of demand for timber products presented above have been in standard units of measure, that is, board feet of lumber, square feet of plywood, cords of pulpwood and fuelwood, and cubic feet of other industrial roundwood products. In order to compare demand for these products with projections of timber supplies, these projections must be converted to common units of measure — cubic feet of roundwood and board feet of sawtimber.

Improvements in utilization. — An important factor in converting demands for timber products to roundwood is prospective change in utilization practices. In recent decades, in response to rising stumpage costs, there have been substantial improvements in utilizing the timber harvested from forests. Improvements have involved an increasing use of slabs, edgings, sawdust, veneer cores, shavings, and other similar material for pulp and particleboard. Various technological developments such as thinner saws and automatic patching and stitching in veneer mills have led to increased product yield per unit of wood input, although in the lumber industry this apparently has been offset by the use of smaller and lower quality material and the spreading use of low-yield (lumber) equipment such as chipping headrigs. Yields in the pulp industry have been held down by a large rise in the production of bleached and semi-bleached pulps which require more wood per ton of production.

With respect to the future, it has been assumed that there would be significant increases in timber product yields over the projection period. These increases under base level price trend assumptions average about 10 percent for lumber, plywood,[22] and woodpulp. These percentages would, of course, be larger under the equilibrium (higher) price trend assumptions discussed below. The opportunities for further improvement are discussed later.

Projected demands for roundwood. — In 1977, U.S. consumption of timber products in terms of roundwood volume was 13.7 billion cubic feet, slightly below the high of 13.8 billion cubic feet reached in 1973, but significantly above the levels of the 1950's and early 1960's when consumption was generally below 12 billion cubic feet a year.

Increases in projected roundwood demands are substantial over the projection period (tables 6.5 and 6.6). For example, the medium projection of demand under base level price trends reaches 22.7 billion cubic feet in 2000, with a continuing rise to 28.3 billion cubic feet in 2030, more than double consumption in 1976 and 1977. Much of the projected increase in demand is for pulp products; consequently pulpwood accounts for about 45 percent of the total demand for roundwood in 2030, compared with a third in 1976.

Growth in roundwood consumption in the 1960's and 1970's consisted entirely of timber produced from softwood species. Consumption of hardwood roundwood has remained at about the same level since the late 1950's.

Projections show rather large increases for both softwoods and hardwoods. Assuming base level price trends, the medium projection of demand for softwoods is up 82 percent by 2030 — from 10.3 in 1976 to 18.7 billion cubic feet. Demand for hardwoods is projected to more than triple, rising from 3.0 to 9.6 billion cubic feet. The faster rate of growth for hardwoods largely reflects the projected rise in demand for hardwood roundwood for pulp products, hardwood lumber for pallets and railroad ties, and hardwood plywood and veneer for furniture manufacture.

Demand for sawtimber products. — About three-fourths of the roundwood consumed in 1976 came from the sawlog portion of sawtimber-size trees. Trends in consumption of sawtimber have been similar to the trends for roundwood (tables 6.5 and 6.6). The projections show continuation of this similarity. By 2030, projected medium demands with base level price trends total about 78.6 billion board feet for softwoods and 30.9 billion board feet for hardwoods.

[21] Decker, H. V. Wood energy, just a word of caution. Guest editorial in the Northern Logger. March. 1979.

[22] It was assumed that yields of lumber and plywood would increase 10 percent in each of the geographic regions used in this report (see frontispiece). Because of differences in the average yields in each region and projected shifts in output among regions, the national average increase in yield is somewhat below 10 percent.

In recent decades, there have been substantial improvements in utilizing timber harvested from forests. Small inefficient mills, such as this small sawmill, are largely things of the past.

The above projections represent total domestic demands for roundwood and sawtimber. A part of these demands will be met by imports. There will also be a substantial export demand. Thus, in deriving demands on domestic forests, it is necessary to take into account projected trade in timber products.

Trade in Timber Products

In the early 1900's, the United States changed from a net exporter of timber products to a net importer, and since that time has depended to an increasing degree on Canada and other countries as a source of supply. Even so, exports have been growing; and the United States has remained an important source of timber products for many countries, especially those in western Europe and Japan.

Post-World War II recovery of the Japanese and European economies, coupled with trade liberalization and expansionary monetary and fiscal policies in the 1950's and 1960's, has led to a severalfold expansion in the economies of industrialized countries. This has had profound impact on trade in timber products including that of the United States, which has in general followed the world pattern.

Trends in Timber Product Exports

Most of the growth in timber product exports has occurred since the early 1950's — the volume has increased from 0.1 billion cubic feet roundwood equivalent[23] to 1.5 billion cubic feet in 1978 (fig. 6.2). This volume represented about 13 percent of the roundwood produced in domestic forests.

[23] "Roundwood equivalent" represents the volume of logs or other round products required to produce the woodpulp, paper, plywood, or other processed materials imported or exported. It is recognized that portions of imports (and exports) of products such as woodpulp are produced from plant residues and thus do not actually represent direct roundwood use. Roundwood equivalent data do indicate relative volumes of traded products and provide a measure of trade that is comparable to the estimates of demand presented above.

Table 6.5—*Summary of total United States softwood timber demand, exports, imports, and demand on and supply from domestic forests, 1952, 1962, 1970, and 1976, with projections to 2030 (medium level) under alternative price assumptions*

(Billion cubic feet)

Item	1952[1]	1962[1]	1970[1]	1976[1]	Projections									
					Base level price trends[2]					Equilibrium price trends[3]				
					1990	2000	2010	2020	2030	1990	2000	2010	2020	2030
Total demand[4]	8.3	8.6	9.9	10.3	15.0	16.3	17.7	18.2	18.7	13.5	14.5	15.5	16.0	16.3
Exports	.2	.4	1.2	1.3	1.3	1.2	1.1	1.0	.9	1.3	1.2	1.1	1.0	.9
Imports	1.3	1.7	2.1	2.4	3.7	3.7	3.9	3.9	3.9	3.2	3.6	3.6	3.5	3.2
Demand on domestic forests[5]	7.2	7.3	9.0	9.2	12.6	13.8	14.9	15.3	15.7	11.6	12.1	13.0	13.5	14.0
Supply from domestic forests[6]	7.2	7.3	9.0	9.2	10.4	11.1	11.6	12.0	12.3	11.6	12.1	13.0	13.5	14.0
Supply-demand balance	0	0	0	0	-2.2	-2.7	-3.3	-3.3	-3.4	0	0	0	0	0
(Billion board feet, International ¼-inch log rule)														
Total demand[4]	39.9	41.7	46.9	50.9	70.3	73.0	78.1	78.7	78.6	60.1	61.9	64.5	64.3	62.1
Exports	.8	1.6	5.7	6.8	7.1	6.4	6.1	5.7	5.4	7.1	6.4	6.1	5.7	5.4
Imports	2.4	4.6	5.9	7.8	13.5	12.8	12.6	11.9	11.2	13.2	13.8	13.6	12.0	10.2
Demand on domestic forests[5]	38.3	38.7	46.7	49.9	63.9	66.6	71.6	72.5	72.8	54.0	54.5	57.0	58.0	57.3
Supply from domestic forests[6]	38.3	38.7	46.7	49.9	48.1	50.5	52.5	54.3	55.6	54.0	54.5	57.0	58.0	57.3
Supply-demand balance	0	0	0	0	-15.8	-16.1	-19.1	-18.2	-17.2	0	0	0	0	0

[1] Data are estimates of actual consumption or harvests and differ somewhat from the "trend" estimates shown in the following section on timber supplies.

[2] Projections show timber demand, imports and supply from domestic forests assuming that the price trends in the base period used in making projections (roughly from the late 1950's through the mid 1970's) continue through the projection period.

[3] Projections show timber demand, imports and supply from domestic forests assuming that prices rise enough to maintain an equilibrium between projected demand and supply.

[4] Total demand for products converted to a roundwood equivalent basis. The projections include adjustments for increased product yield per unit of roundwood input which are expected to result from improvements in utilization.

[5] Total U.S. demand plus exports minus imports.

[6] The base level projections show the volume of timber available for harvest from domestic forests if recent trends in the forces determining supply, such as commercial timberland area, management and prices continue through the projection period.

Note: Data may not add to totals because of rounding.

Sources: Data for 1952, 1962, 1970, and 1976 based on information published by the U.S. Departments of Agriculture and Commerce.

Projections: U.S. Department of Agriculture, Forest Service.

Table 6.6 — *Summary of total United States hardwood timber demand, exports, imports, and demand on and supply from domestic forests, 1952, 1962, 1970, and 1976, with projections to 2030 (medium level) under alternative price assumptions*

(Billion cubic feet)

Item	1952[1]	1962[1]	1970[1]	1976[1]	Projections									
					Base level price trends[2]					Equilibrium price trends[3]				
					1990	2000	2010	2020	2030	1990	2000	2010	2020	2030
Total demand[4]	3.6	3.1	3.0	3.0	5.3	6.4	7.5	8.7	9.6	5.3	6.4	7.3	8.5	9.2
Exports	[5]	.1	.2	.2	.2	.2	.4	.4	.4	.2	.2	.4	.4	.4
Imports	.1	.2	.3	.3	.6	.6	.6	.6	.6	.6	.6	.6	.6	.6
Demand on domestic forests[6]	3.6	3.0	2.9	2.9	4.9	6.0	7.3	8.5	9.4	4.9	6.0	7.1	8.3	9.0
Supply from domestic forests[7]	3.6	3.0	2.9	2.9	4.9	6.0	7.1	8.1	8.9	4.9	6.0	7.1	8.3	9.0
Supply-demand balance	0	0	0	0	0	0	-.2	-.4	-.5	0	0	0	0	0
(Billion board feet, International ¼-inch log rule)														
Total demand[4]	11.7	11.6	12.4	11.6	17.8	21.2	24.7	28.2	30.9	15.9	19.6	23.4	27.6	30.2
Exports	.2	.3	.5	.7	.7	1.0	1.2	1.2	1.3	.7	1.0	1.2	1.2	1.3
Imports	.4	.9	1.4	1.5	2.0	2.2	2.5	2.6	2.5	2.0	2.2	2.5	2.6	2.5
Demand on domestic forests[6]	11.5	11.0	11.5	10.8	16.5	20.0	23.4	26.8	29.7	14.6	18.4	22.1	26.2	29.0
Supply from domestic forests[7]	11.5	11.0	11.5	10.8	14.7	18.5	21.9	25.4	27.5	14.6	18.4	22.1	26.2	29.0
Supply-demand balance	0	0	0	0	-1.8	-1.5	-1.5	-1.4	-2.2	0	0	0	0	0

[1] Data are estimates of actual consumption or harvests and differ somewhat from the "trend" estimates shown in the following section on timber supplies.

[2] Projections show timber demand, imports and supply from domestic forests assuming that the price trends in the base period used in making projections (roughly from the late 1950's through the mid 1970's) continue through the projection period.

[3] Projections show timber demand, imports and supply from domestic forests assuming that prices rise enough to maintain an equilibrium between projected demand and supply.

[4] Total demand for products converted to a roundwood equivalent basis. The projections include adjustments for increased product yield per unit of roundwood input which are expected to result from improvements in utilization.

[5] Total U.S. demand plus exports minus imports.

[6] The base level projections show the volume of timber available for harvest from domestic forests if recent trends in the forces determining supply, such as commercial timberland area, management and prices continue through the projection period.

Note: Data may not add to totals because of rounding.

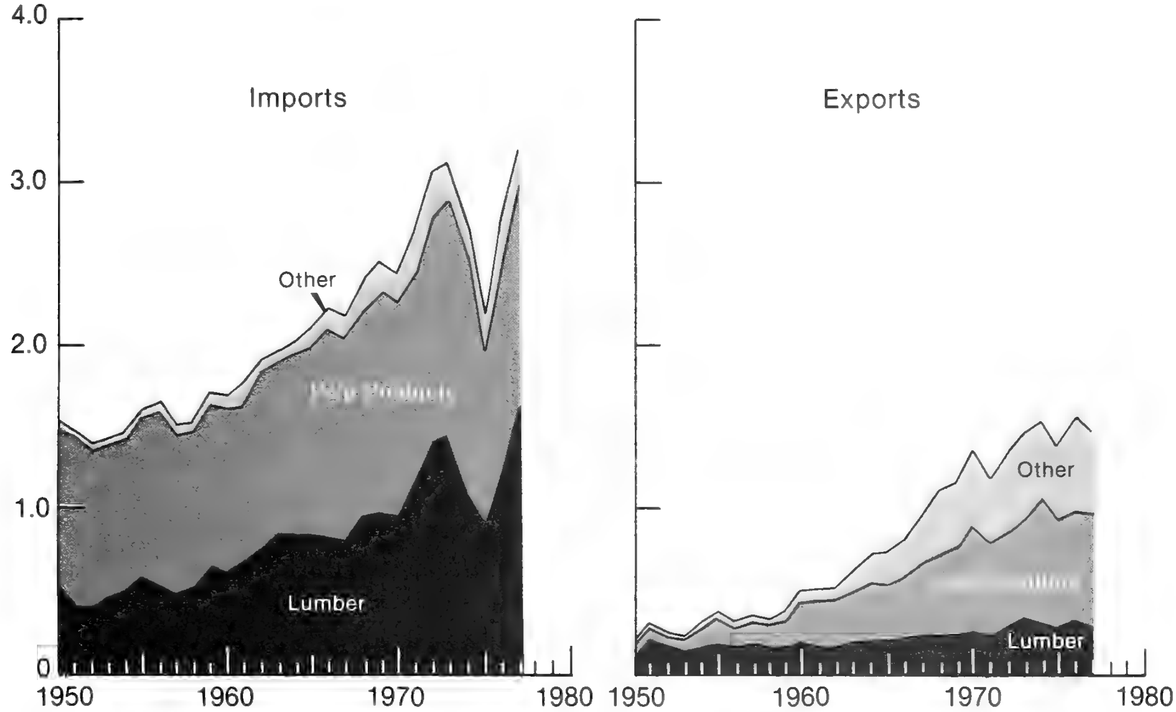
Sources: Data for 1952, 1962, 1970, and 1976 based on information published by the U.S. Departments of Agriculture and Commerce.

Projections: U.S. Department of Agriculture, Forest Service.

Figure 6.2.

Imports and Exports of Timber Products

Bil. Cubic Ft., Roundwood Equivalent



Exports of lumber, chiefly softwoods, have tripled since the early 1950's, rising from 0.1 billion cubic feet roundwood equivalent (0.5 billion board feet) to 0.3 billion cubic feet in 1978 (1.8 billion board feet)—a volume equal to about 5 percent of United States production. The bulk of the increased shipments in recent years has gone to Japan and Canada, with smaller amounts to Europe, Latin America, and other countries.

Most of the increased lumber exports to Japan have originated in Alaska. These exports peaked at about 400 million board feet in 1973. The potential exists for increases in lumber production in the interior of Alaska, and timber harvest may be accelerated in Southeast Alaska on lands selected by Alaskan Natives. This could result in a further rise in softwood lumber exports to Japan.

Exports of pulp products also grew rapidly in the 1950-78 years moving up from 50 million cubic feet to about 0.7 billion cubic feet roundwood equivalent. This represented about 20 percent of domestic production. The bulk of the increase in exports of pulp products has been in the form of pulp and linerboard shipped to Western Europe and the Far East, principally to Japan.

Pulp chips produced from slabs and other byproducts of primary timber processing plants on the Pacific Coast have made up an increasing part of the shipment of pulp products to Japan since the mid-1960's. Small volumes of roundwood pulpwood have also been exported to Canada. In addition, a growing, but still relatively small, trade has developed in the export of chips from the South to Scandinavia.

Exports of products such as plywood and veneer, poles, piling, etc., have grown; but the volumes involved have represented a small part of United States production.

The volume of logs exported has increased rapidly since the early 1950's, rising from 10 million cubic feet to about 0.5 billion cubic feet in 1978 (3.4 billion board feet local log scale). By far the largest part of these exports consisted of softwood logs (3.3 billion board feet in 1978), with 80 percent of these going to Japan. In 1976, these softwood log exports amounted

to about 8 percent of the softwood sawtimber harvest.

In part because of devaluation of the U.S. dollar relative to Japanese and European currencies, the total and average value of log exports have also increased rapidly in recent years. For example, the total value of log exports in 1978 was $1,180 million with an average value of $346 per thousand board feet, log scale. Shipments during the last half of 1978 and the first half of 1979 were averaging well over $400 per thousand board feet.

The rapid rise in the volume and value of softwood log exports has caused a substantial amount of controversy. This has been centered on the shipments from the Pacific Northwest where about 85 percent of the logs originate. About 70 percent of the softwood log exports from this region come from private land, nearly all from those in forest industry ownership, and 30 percent from lands managed by the State of Washington. Export of logs cut from timber on Federal lands and State of Oregon lands is prohibited, with minor exceptions, by Federal and State laws.[24]

Opponents of softwood log exports have generally argued that if these logs were not exported, they would be processed domestically, contributing to employment and helping to lower domestic stumpage and softwood end product prices. Proponents have generally argued that little of the volume exported under current regulations would be processed domestically and that the export market contributes to employment and improved timber management.

The effects, in Japan and the United States, of further restrictions on softwood log exports cannot be predicted with any certainty, they would depend in large part on Japanese reactions. Logs from the United States amount to about 25 percent of Japan's consumption of softwoods and are used primarily for housing construction. Logs from New Zealand, the Soviet Union, and domestic sources and lumber from the United States and Canada are Japan's alternative sources of softwood construction materials. If United States log exports were restricted, the Japanese responses could range from relying to a greater degree on other countries, to increasing lumber imports from United States sources.

Timber owners in the Pacific Northwest could also respond to restrictions on log exports in various ways — ranging from trying to sell more logs in the domestic market, to building additional processing facilities, to storing the timber on the stump in the hope that rising timber prices would make storage worthwhile. Timber processors in the Pacific Northwest could expand capacity and attempt to sell the additional lumber output in the domestic or Japanese market.

In general, the Japan-Canada-United States triangular trade in softwood logs and lumber would tend to limit the effects of restrictions on softwood log exports on domestic softwood lumber markets. If Japan did purchase additional lumber from the Pacific Northwest after restrictions on log exports, lumber imports from Canada and production in other United States regions would tend to increase in response to an associated rise in prices. This, in turn, would tend to alleviate the impact of expanded United States lumber exports on domestic end product prices.

A recent study[25] simulated in a quantitative way the effects of alternative Japanese, Canadian, and United States' responses to a ban on softwood log exports. This analysis showed that, in general, such a ban would reduce softwood lumber prices in the United States only if Japan turned to sources outside North America for construction materials and only if lumber processing capacity expanded significantly on the West Coast of the United States. The softwood lumber price decline associated with these types of market responses would be on the order of 2 to 3 percent. Stumpage prices would tend to fall in all United States supply regions, with the largest drop — on the order of 10 percent — in the Pacific Northwest.

The analysis further showed that softwood lumber prices in the United States would rise on the order of 2 to 3 percent if the Japanese purchased lumber from North America to replace the log imports and if processing capacity did not expand significantly. With these responses, stumpage prices in the Pacific Northwest would decline by roughly 10 percent and by a larger amount in western Washington.

There has also been some controversy over the export of hardwood logs from the eastern United States. Although the volumes involved are small, 110 million board feet in 1978, they are largely made up of high value and relatively scarce species and thus have had some effects on domestic markets. For example, export of walnut logs, principally to western Europe, has been a contributing factor in the very large increases in walnut log and stumpage prices that have taken place in recent years.

[24] Lindell, Gary R. Log export restrictions of the western States and British Columbia. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. PNW-63. Pacific Northwest For. and Range Exp. Sta., Portland, Oregon. 14 p., illus. 1978.

[25] Darr, David R., R. W. Haynes, and Darius M. Adams. The impact of the export and import of raw logs on domestic timber supplies and prices. (In process.)

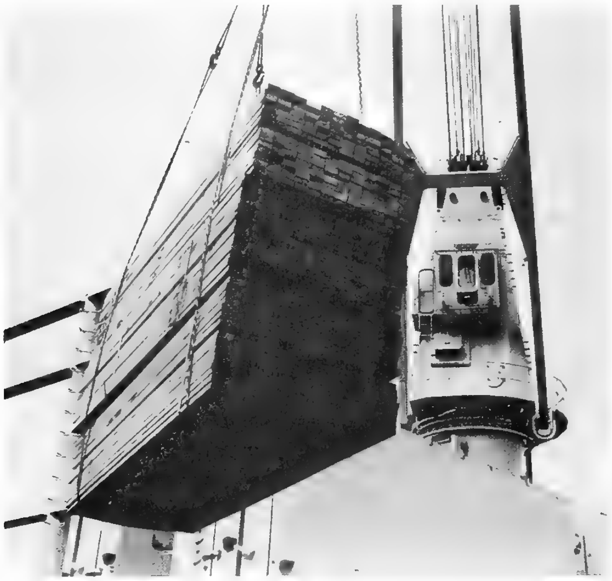
Trends in Timber Product Imports

Imports of timber products have followed about the same upward trend as exports, rising from 1.5 billion cubic feet roundwood equivalent in 1950 to 3.2 billion in 1978 (fig. 6.2). The 1978 imports represented more than a fifth of the total United States consumption of timber products.

Between 1950 and 1978, lumber imports grew from 0.5 billion cubic feet (3.4 billion board feet) to 1.6 billion cubic feet (12.2 billion board feet) — a rise that accounted for more than half of the total expansion in imports during this period. Nearly all of the increase was composed of softwoods from Canada, chiefly from British Columbia. By the mid-1970's, imports amounted to more than 20 percent of U.S. softwood lumber consumption. Hardwood lumber imports, mostly from the tropical regions of the world and from Canada, fluctuated between 0.2 and 0.5 billion board feet per year.

Imports of woodpulp, newsprint, and other grades of paper and board have also increased since 1950, reaching 1.4 billion cubic feet in 1977. In the mid-1970's, imports of pulp products amounted to 30 percent of U.S. consumption, down from 37 percent in the early 1950's. Nearly all of these imports have originated in Canada.

Softwood lumber imports from Canada have grown rapidly and now account for over a fifth of U.S. consumption. There is also a substantial export trade.



Although not large in terms of cubic volume, hardwood plywood and veneer imports have grown rapidly since 1950, rising from 5 million to 195 million cubic feet in 1977. Korea, Taiwan, Japan, and the Philippines have been the source of nearly all the added imports. Most of the timber used in the manufacture of these products, however, has originated in tropical hardwood forests in Malaysia, Indonesia, and the Philippines. In the mid-1970's, imports of hardwood veneer and plywood amounted to about 65 percent of U.S. consumption of these products.

Small volumes of logs, softwood plywood, particleboard, and miscellaneous roundwood products such as posts and poles also have been imported. Most of these imports have been cross-border trade with Canada.

Future trends in United States trade in timber products will largely depend on the economic availability of timber in the major forested regions of the world, and on the timber demand-supply price situation in the major consuming areas. Demand in western Europe and Japan is of particular significance in estimating export trends. The timber situation in Canada, the source of most imports, and to a lesser extent in the world's tropical hardwood areas, is of primary importance in appraising future prospects for imports.

Trends in World Timber Demands

Consumption of industrial timber products has been growing rapidly in all parts of the world. In total, it increased from 26 billion cubic feet roundwood equivalent in 1950 to over 49 billion in 1977, a rise of nearly 90 percent. Several studies point to further substantial increases in demand in the decades ahead.[26]

[26] Examples of relevant studies include:

Buongiorno, Joseph, and Gerold L. Grosenick. Impact of world economic and demographic growth on forest products consumption and wood requirements. Canadian J. For. Res. 7(2): 392-399. 1977.

Food and Agriculture Organization of the United Nations. Development and forest resources in the Asia and Far East region. Rome. 89 p. 1976.

———— Development and investment in the forestry sector. FO:COFO-78/2, Rome. 21 p. March, 1978.

Food and Agriculture Organization of the United Nations and United Nations Economic Commission for Europe. European timber trends and prospects: 1950 to 2000. Supplement 3 to Vol. XXIX of the Timber Bulletin for Europe. Geneva. 308 p. 1976.

Madas, Andras. World consumption of wood: Trends and prognoses. Akademiai Kiado, Budapest, Hungary. 130 p. 1974.

Pringle, S. L. Tropical moist forests in world demand, supply and trade. Unasylva 28 (112-113): 106-118. 1976.

The situation in Europe. — In 1976, an estimated 11.2 billion cubic feet of industrial wood — about a quarter of world production — was consumed in Europe, excluding the Soviet Union. Projections of the Food and Agriculture Organization of the United Nations and the Economic Commission for Europe[27] indicate that this upward trend is likely to continue with the expansion of European economies. Projected demands for industrial timber products roughly double by 2000. Most growth is for pulp and paper products and wood-based panels. Demands for lumber are expected to increase about as rapidly as population growth.

Studies of the prospective European timber supply situation indicate that timber supplies from European forests could be expanded, and that significant improvements in utilization could result from increased residue use and recycling of paper and paperboard. However, even with the most favorable set of supply and demand projections, Europe is expected to have a deficit of about 10 billion cubic feet in the year 2000, and it might reach 14 billion cubic feet. This compares with an annual deficit of 1.5 billion cubic feet in the 1969-71 period.

With respect to the United States, the European outlook suggests continuing increases in European demands for pulp and paper products. In the case of lumber and logs, it seems likely that most of the growth will be supplied by imports from the Soviet Union, Canada, and the world's tropical hardwood regions.

The timber demand-supply situation in Japan. — The phenomenal economic growth in Japan between 1950 and 1977 resulted in a sixfold increase in industrial wood consumption to 3.5 billion cubic feet roundwood equivalent.

Although Japan is heavily forested, its timber resources are limited in relation to population. In addition, Japanese forests were severely depleted by heavy cutting during World War II. To meet rising demands, imports of logs and other products into Japan have increased rapidly, and in 1977 amounted to 2.3 billion cubic feet — 66 percent of total Japanese supplies.

For many years, Japanese imports were mainly tropical hardwood logs used in the manufacture of plywood; since the early 1960's, imports of softwood logs for the manufacture of lumber, and imports of chips for pulp manufacture, have shown large increases. Most of the softwood log imports have originated in the United States and the Soviet Union. Lumber imports, primarily softwoods from Canada and the United States, are equal to about 10 percent of the volume of imported logs. By far the largest part of the pulp chip imports has come from the United States. Canada and the United States also have supplied most of the growing amounts of pulp and paper imports.

Estimates of the Japanese Forestry Agency indicate that demand for timber products will rise to 5.2 billion cubic feet by 1991, some 1.7 billion cubic feet above consumption in 1977. Beyond the 1980's, Japanese forests are expected to be capable of supplying an increasing share of the country's total demands, but imports will remain critical in supplying the country's needs for timber products. In 1991, for example, imports are projected to amount to 60 percent of total consumption. Thus, even with successful implementation of domestic timber supply programs, Japan is likely to continue to be a major importer of timber products from North America, Siberia, and Southeast Asia during the next few decades.

Future softwood log and lumber exports from the United States to Japan will depend in part on the level of Japanese housing starts. During the past decade, housing starts in Japan have generally ranged between 1.5 and 1.7 million per year — about four times the average in the early 1960's. On a per capita basis, current construction is about twice the rate of construction in the United States. The high level of construction reflects Japanese programs to upgrade the housing inventory. A large part of the units built, as much as two-thirds in recent years, has been to replace existing units. This high replacement rate cannot be continued for long and it seems likely that there will be a substantial fall-off fairly early in the projection period. A development of this kind would, of course, reduce demands for imported softwood logs and lumber.

In the Pacific Northwest, most of the old-growth timber inventory on forest industry lands and on lands managed by the State of Washington, the sources of nearly all softwood log exports, will have been harvested by the 1990's. As these old-growth stands are cut, the decline in availability of this high-quality timber will tend to adversely affect the current comparative advantage in the export of softwood logs and lumber. At the present time, it is not clear whether the Japanese would be willing to purchase second-growth saw logs in the same quantities that they now purchase primarily old-growth. Instead of continuing to purchase saw logs from the United States, Japanese importers might expand imports of

[27] Food and Agriculture Organization of the United Nations and Economic Commission for Europe. European timber trends and prospects: 1950 to 2000. Supplement 3 to Vol. XXIX of the Timber Bulletin for Europe, Geneva. 308 p. 1976.

softwood saw logs and/or lumber from the Soviet Union, Canada, and New Zealand, and possibly other sources. Softwoods from domestic forests might also contribute a larger share of supply.

The timber demand-supply situation in other countries and regions. — Although most of the United States export trade in timber products has been with Europe and Japan, significant exports of woodpulp, paper and board, lumber, logs, veneer, and plywood have gone to other countries. For example, there has been considerable growth in softwood lumber and paper and board exports to Canada, and paper and board exports to Central and South America. Trade in other timber products with other regions has been important, but exports have shown only slow growth or been stable over the 1960's and 1970's.

In general, demands for timber products are rising in these areas. However, many have substantial forest resources. These resources, along with the development of domestic timber processing facilities, are likely to significantly affect the future levels of United States exports. Plans for pulp and other types of timber processing complexes for numerous countries in Asia, Africa, and South America generally have a reduction in imports as one of the goals of development. If and when these plans come to fruition, they could have a significant impact on world trade patterns, especially for hardwood logs, lumber and plywood, pulp and paper, and board.

Most of the high-quality, old-growth softwood timber on State and forest industry lands on the Pacific Coast will be harvested by the 1990's.

World Forest Land and Timber Resources

Future United States trade in timber products will be influenced by the trends in demands in the major consuming areas discussed above. Trade will also be influenced by the supplies of timber in the timber-producing regions of the world.

There are an estimated 7.5 billion acres of forest land with 20 percent or more tree crown cover in the world. Most of the hardwood forests are in Latin America and the tropical regions of Africa and Southeast Asia. The softwood acreage is concentrated in the Soviet Union and in North America.

The world's forests contain an estimated 11.4 trillion cubic feet of timber (table 6.7). Softwoods make up one-third of this timber inventory. North America and the Soviet Union contain the largest volumes of softwood growing stock, while Latin America, Africa, and Southeast Asia have most of the hardwood volumes.

Table 6.7. — *Forest growing stock in the world, by area and species group*

(Billion cubic feet)

Area	Total	Soft-wood	Hard-wood
North America	1,288	953	335
Latin America	3,260	92	3,168
Europe	526	335	191
Africa	2,134	4	2,130
Asia-Pacific (except Japan)	1,330	201	1,129
Japan	71	39	32
Soviet Union	2,790	2,366	424
World	11,399	3,990	7,409

Source: Adapted from Pringle, S. L. Tropical moist forests in world demand, supply and trade. Unasylva. 28 (112-113): 106-108. 1976.

In 1973, the total world harvest of industrial roundwood was about 48 billion cubic feet, with about 60 percent of this volume coming from softwood forests in North America, the Soviet Union, and Europe.

About 70 percent of the hardwood timber came from the forests on North America, Asia, and Europe — even though these areas contain only 22 percent of the world's hardwood growing stock inventory. Latin America contains nearly half the total world hardwood resources, but accounted for less than 8 percent of world industrial hardwood supplies in 1973.

Timber supply potential. — Hardwood forests in many regions of the world, including the United States, could support higher levels of harvest in the next several decades. Most of this apparent potential is in the tropical hardwood forests of Latin America, Southeast Asia, and Africa.

The tropical hardwood forests are extensive and have a large capacity for timber growing. Yet serious problems exist which offset the capability of these forests to continue to supply high-quality timber products to world markets. Much of the tropical forest area is relatively inaccessible. Only 22 percent of the Brazilian closed forest is considered accessible. Hence, development of timber resources is slow and expensive. Utilization of timber is complicated by the great numbers of widely different species that oftentimes have unknown characteristics. Such problems of heterogeneity occur in all regions but are particularly acute in Latin America. The future of tropical forests in all regions is further complicated by the expanding need for agricultural land to accommodate rapidly growing populations, and a lack of knowledge of proper management techniques.

Softwood timber supplies, for use in domestic markets or for sale in international markets, can be augmented in three ways: (1) Intensification of timber management, (2) improved utilization, and (3) expanded harvest in currently undeveloped areas. The rising prices for timber products expected in world markets will provide an incentive for intensification of timber management. However, the impact on softwood supplies probably will be minimal for two or three decades, except in unique situations where old-growth inventories permit an immediate increase in harvest.

Improved utilization can have a more immediate effect on supplies. The largest part of the expected increase in world demands for industrial timber products is for pulp and particleboard. This should enhance the possibility of expanded management and utilization since smaller trees, lower quality logs, and manufacturing byproducts can be more easily used for such products than for those manufactured directly from solid wood.

Conservation of wood fiber through expanded recycling of paper and paperboard in the industrialized countries of the world offers another possibility for meeting a significant portion of growing world demands for pulp products. In the United States, about 19 percent of paper and paperboard is recycled and in Japan, 40 percent.

Possibilities for expanded output of softwood lumber and plywood outside the United States in the years immediately ahead seem to be limited to currently undeveloped resources in the northern parts of Canada and Siberia. Both Canada and the Soviet Union have indicated a desire to develop their forest resources. Unused timber in both countries is under government control, and hence government policies — as well as trends in prices, markets, and availability of investment capital — will be significant factors in determining how rapidly expansion of timber output takes place.

The softwood timber resources of Canada are of special significance to the United States, for both geographic and economic ties make Canada a primary timber supply region for this country. Canada is the leading timber-exporting nation in the world, with three-fourths of its exports going to the United States.

The 1976 Canadian timber cut of about 5.0 billion cubic feet (4.6 billion softwoods) was well below the calculated gross physical annual allowable cut of 9.8 billion cubic feet (7.3 billion softwoods). Intensification of timber management and improved utilization could expand these allowable cuts significantly, but the ultimate potential is unknown. The present unused allowable cut, for the most part, is in the undeveloped northern parts of the Canadian Provinces where utilization will involve high development costs.

Only a portion of the unused gross physical annual allowable cut, about 3 billion cubic feet, was considered economically accessible in 1976. The rising equilibrium prices projected in this analysis will help to make more of the Canadian softwood resource economically available and will enhance the rationale for more intensive management and improved utilization in the accessible areas.

In 1976 Canada had the timber resources to expand timber output. In terms of products, a recent study[28] showed that the production of softwood lumber could be increased to about 21 billion board feet on a sustained basis, some 7.5 billion board feet above output in 1973-74. If economic accessibility is taken into account, the production potential would decline to about 18 billion board feet. Over one-half of the potential for increased Canadian softwood lumber production existed in British Columbia, especially in the interior of the Province.

For pulp production, the combined potential of economically assessible hardwoods and softwoods indicated that these reserves could support increased output of 6.2 million tons. Physical reserves are available to support about 10 million tons of additional production.

There is, of course, a lot of uncertainty associated with the above estimates. At best, they are judgments based on the information available, and as such are

[28] Reed, F. L. C. and Associates Ltd. Canada's reserve timber supply, prepared for the Department of Industry, Trade and Commerce, Ottawa, Ontario. 1974. F. L. C. Reed and Associates Ltd., Forest Management in Canada, Vol. I. Prepared for the Forest Management Institute of the Canadian Forestry Service, Ottawa, Ontario. 1977.

subject to change as market conditions and information changes. They do reflect, however, the reality that the timber resource of Canada can support larger harvests and, further, that the resource is not unlimited. Since the 1950's, Canada has been able to rapidly expand output of all timber products through development of previously untapped resources. Further expansion in this manner is likely to be increasingly constrained in the 1980's. It seems evident that expansion of production of pulp, paper, and softwood lumber in Canada will depend more on intensification of timber management and improvement of utilization practices than an expansion at the extensive margins of timber reserves.

Prospective Trends in U.S. Timber Product Trade

As described above, the available data on future demands in the major consuming countries and regions of the world suggest continuing and rapid growth for pulp and paper products. In view of the competitive position of the United States in producing these products, exports are likely to rise.

Demands for solid wood products in most consuming areas are also expected to grow although there may be some decline in Japan for softwood logs and lumber as housing construction drops off. The projected timber supply situation on the Pacific Coast suggests a lessening of the U.S. comparative advantage in old-growth logs and clear lumber of large dimensions. As a result of this and the market outlook in Japan, exports of logs, lumber, and plywood after 1990 are expected to decline.

Effective trade promotion in major consuming areas, or action to increase timber supplies, could greatly change the outlook for exports. As indicated in other places in this chapter, domestic forests have the potential under intensive management of meeting prospective growth in domestic demands while at the same time supporting large increases in exports.

The United States will continue to be a major importer of timber products. This pattern is expected because of the unique nature of some products and limitations on domestic timber supplies. The largest increases in imports are expected in softwood lumber and pulp and paper products from Canada. It also seems likely that the United States will continue to draw on tropical forests for hardwood plywood and veneer for some time to come, in spite of the uncertainties surrounding the long-term outlook.

The projected export-import levels for the United States in terms of roundwood equivalent are summarized in tables 6.5 and 6.6. The data in these tables show that imports of timber products are likely to continue to grow until 2000 and exceed exports by a substantial margin through the projection period. Although there is some growth in net imports to 2020, it is clear that the volume of timber products available for use beyond 2000 will be increasingly determined by the domestic timber resource situation.

Demand for Timber from Domestic Forests

Although improvements in utilization and the expected increase in net imports can meet part of the projected growth in demand for timber products, these potentials are relatively small in comparison to total growth in demand at something close to the increase in prices in the period used as the projection base. Thus, the United States must look to its domestic timber resources as the best hope of meeting future demands for timber products.

Production of softwood roundwood from domestic forests showed little change in the 1950's. A fairly fast increase was evident in the 1960's and 1970's (table 6.5). Production of softwood sawtimber from U.S. forests followed similar trends. In contrast, production of hardwoods — roundwood and sawtimber — remained about the same from 1962 through 1976 (table 6.6).

The primary timber processing industries include plants manufacturing lumber, plywood, wood pulp and a wide variety of other products such as pallets, containers, fence posts and utility poles.

Projected demands for timber from domestic forests (medium level and base level price trends) rise from 12.1 billion cubic feet in 1976 to 25.1 billion cubic feet by 2030—an increase of 107 percent. Associated demands for sawtimber rise from 60.7 to 102.5 billion board feet.

In volume terms the projected rise in demand on domestic forests between 1976 and 2030 is the same for softwood and hardwood roundwood, some 6.5 billion cubic feet. In percentage terms, however, the projected increases are much larger for hardwoods. For example, demands on domestic forests for hardwood roundwood rise some 224 percent between 1976 and 2030, compared to 71 percent for softwoods. Projected demands for hardwood and softwood sawtimber show roughly similar trends.

Primary Timber Processing Industries

Converting these projected increases in demand into products usable by consumers will require a large expansion in domestic primary timber processing industries.[29] These industries include establishments engaged in harvesting timber from the forest (logging) and in manufacturing lumber, veneer and plywood, wood pulp, and other products such as wood containers, pallets, and a wide variety of turned and shaped items.

According to the most recent Census of Manufactures, some 28,000 primary timber processing establishments were operating in the United States in 1972 (table 6.8). These establishments had 633,000 employees and produced products valued at nearly $24.7 billion. Nearly half of the establishments were in the logging industry, i.e., logging camps and contractors. Another third were sawmills and planing mills. Most of the remainder were classified in other primary manufacturing. Although small in number, the 2 percent of the establishments in the plywood and veneer industry and the 1 percent in the woodpulp industry accounted for nearly half of the value of shipments of all primary timber products.

Almost all of the primary timber processing establishments are located near sources of timber. Moreover, timber species, tree size, and quality strongly influence the type and size of processing establishments. For example, the predominantly softwood forests of the South supported a little over 13,000 primary timber processing establishments, 46 percent of the Nation's total in 1972 (table 6.9). The majority of these processors were comparatively small logging contractors and sawmills and planing mills that can efficiently harvest and process the timber produced from the small forest ownerships characteristic of this section of the country.

The predominantly hardwood forests of the North, with essentially the same ownership characteristics, supported 9,000 primary timber processing establishments, nearly a third of the total number. As in the South, the average processing establishment was small.

The softwood forests of the Pacific Coast where trees are comparatively large, and to a lesser degree those in the Rocky Mountains, provide timber for fewer but bigger logging operations and processing establishments. The Pacific Coast, with about 5,000 establishments or 17 percent of the total, produced nearly a third of the value of shipments of all primary timber processing industries in 1972.

There have been some significant changes in the primary timber processing industries in recent decades. For example, the number of establishments has declined from close to 35,000 in 1958 to little more than 28,000 in 1972 (table 6.10). There also was a small drop in employment. In contrast, the value of shipments, measured in constant 1972 dollars, nearly doubled, rising from $12.8 billion to 24.8 billion.

Single establishments, operating at a single geographic location, are the most common form in the primary timber processing industries.[30] This is most evident in the lumber manufacturing industry where 91 percent of the establishments operated at one location. This also is characteristic of establishments in

[29] The primary timber processing industries are composed of the following industries as defined in the Standard Industrial Classification Manual:

— Lumber manufacturing:	1. Logging camps and contractors (SIC 2411)
	2. Sawmills and planing mills (SIC 242)
— Plywood and veneer manufacturing:	1. Hardwood veneer and plywood (SIC 2435)
	2. Softwood veneer and plywood (SIC 2436)
— Woodpulp manufacturing:	1. Pulpmills (SIC 2611)
	2. Paper mills, except building paper integrated in a pulpmill (SIC 2621-12)
	3. Paperboard mills, integrated with a pulpmill (SIC 2631-12)
	4. Building paper and board mills, integrated with a pulpmill (SIC 2662-12)
— Other primary timber manufacturing:	1. Wood containers, pallets, and skids (SIC 244)
	2. Miscellaneous solid wood products (SIC 249)

For more complete definitions, see Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual. 615 p. 1972.

[30] Ellefson, Paul V. and Michael E. Chopp. Systematic analysis of the economic structure of the wood-based industry. Univ. Minnesota, College of Forestry, Dept. Forest Resources. Staff Paper No. 3. 1978.

Table 6.8. — *Establishments, employees and value of shipments in the primary timber processing industries in the United States, by industry, 1972*

Industry	Establishments		Employees		Value of shipments	
	Number	*Percent*	*Thousands*	*Percent*	*Million dollars*	*Percent*
Lumber manufacturing	22,686	80.0	284.1	44.9	9,703.1	39.5
Logging camps and contractors	13,238	46.7	80.0	12.7	2,529.5	10.2
Sawmills and planing mills	9,448	33.3	204.1	32.2	7,173.6	29.3
Plywood and veneer manufacturing	598	2.1	68.8	10.9	2,923.3	11.9
Woodpulp manufacturing	331	1.1	161.0	25.4	8,937.6	36.2
Other primary timber manufacturing	4,760	16.8	119.2	18.8	3,068.7	12.4
Total	28,375	100.0	633.1	100.0	24,632.7	100.0

Source: U.S. Department of Commerce, Bureau of the Census. *Census of Manufactures, 1972. Volume II. Industry Statistics. Part 1. SIC Major Groups 20-26,* U.S. Government Printing Office, Washington, D.C., 1976.

Table 6.9 — *Establishments, employees, and value of shipments in the primary timber processing industries in the United States, by section and region, 1972*

Section and region	Establishments		Employees		Value of shipments	
	Number	*Percent*	*Thousands*	*Percent*	*Million dollars*	*Percent*
North:						
Northeast	4,398	16	83.7	13	2,721.8	11
North Central	4,641	16	94.5	15	3,191.0	13
Total	9,039	32	178.2	28	5,912.8	24
South:						
Southeast	7,167	25	115.5	18	4,332.8	18
South Central	6,053	21	139.3	22	5,256.7	21
Total	13,221	46	254.8	40	9,589,5	39
Rocky Mountains	1,230	4	28.7	5	1,110.4	5
Pacific Coast:						
Pacific Northwest	3,377	12	127.2	20	6,028.8	24
Pacific Southwest	1,508	5	44.2	7	1,991.2	8
Total	4,885	17	171.4	27	8,020.0	32
United States	28,375	100	633.1	100	24,632.7	100

Source: See source note table 6.8.

other primary timber manufacturing industry categories. On the other hand, in the woodpulp industry only a quarter of the establishments operated at one location.

The legal form of organization (i.e., corporate versus noncorporate) is mixed. Only 22 percent of the establishments in the lumber manufacturing industry had a corporate form of organization in 1972, while over nine-tenths of those in the woodpulp, plywood, and veneer manufacturing industries were corporate in nature. Although the importance of a corporate form of legal organization varies by sector within the primary timber processing industries, the bulk of employment, value added by manufacture, and new capital expenditures originates in corporations.

Table 6.10 — *Characteristics of the primary timber processing industries in the United States, by industry, 1958, 1963, 1967, 1972 and 1976*

Industry	Number of establishments					Thousands of employees				
	1958	1963	1967	1972	1976[1]	1958	1963	1967	1972	1976
Lumber manufacturing										
Logging	12,828	13,588	16,334	13,238	—	71.7	73.1	70.6	80.0	71.5
Sawmills and planing mills	16,859	13,677	11,790	9,448	—	282.3	247.7	219.7	204.1	207.5
Total	29,687	27,265	28,124	22,686	—	354.0	320.8	290.3	284.1	279.0
Plywood and veneer manufacturing										
Hardwood veneer and plywood[2]	—	—	—	366	—	—	—	—	25.1	21.9
Softwood veneer and plywood[2]	—	—	—	232	—	—	—	—	43.7	45.0
Total	588	641	667	598	—	59.3	66.2	72.9	68.8	66.9
Woodpulp manufacturing										
Pulpmills	59	45	61	60	—	14.2	15.1	15.1	10.6	15.7
Integrated pulpmills[3]	266	215	218	271	—	133.4	132.2	142.4	150.4	144.4
Total	325	260	279	331	—	147.6	147.3	157.5	161.0	160.1
Other primary timber manufacturing	4,312	4,220	4,442	4,760	—	99.7	100.2	113.9	119.2	114.7
All industries	34,912	32,386	33,512	28,375	—	660.6	634.5	634.5	633.1	620.7

	Value of shipments in millions									
	Current dollars					*1972 dollars*[4]				
	1958	1963	1967	1972	1976	1958	1963	1967	1972	1976
Lumber manufacturing										
Logging	868.3	1,154.7	1,476.2	2,529.5	4,460.8	1,093.6	1,438.0	1,740.8	2,529.5	2,877.9
Sawmills and planing mills	3,302.8	3,648.0	4,046.9	7,173.6	9,752.0	4,159.7	4,543.0	4,772.3	7,173.6	6,291.6
Total	4,171.1	4,802.7	5,523.1	9,703.1	14,212.8	5,253.3	5,981.0	6,513.1	9,703.1	9,169.5
Plywood and veneer manufacturing										
Hardwood veneer and plywood[2]	—	—	—	911.8	970.1	—	—	—	911.8	625.9
Softwood veneer and plywood[2]	—	—	—	2,011.5	3,164.1	—	—	—	2,011.5	2,041.4
Total	884.1	1,339.6	1,687.2	2,923.3	4,134.2	1,113.5	1,668.2	1,989.6	2,923.3	2,667.2
Woodpulp manufacturing										
Pulpmills	428.0	609.1	730.5	709.9	2,055.4	539.0	758.5	861.4	709.9	1,326.1
Integrated pulpmills[3]	3,460.9	4,189.7	5,437.3	8,227.7	14,202.0	4,358.8	5,217.6	6,411.9	8,227.7	9,162.6
Total	3,888.9	4,798.8	6,167.8	8,937.6	16,257.4	4,897.8	5,976.1	7,273.3	8,937.6	10,488.7
Other primary timber manufacturing	1,197.1	1,434.2	2,078.3	3,068.7	4,338.0	1,507.7	1,786.1	2,450.8	3,068.7	2,798.7
All industries	10,141.3	12,375.3	15,456.4	24,632.7	38,492.4	12,772.4	15,411.3	18,226.9	24,632.7	24,833.8

[1] Number of establishments not available for intercensal years.

[2] Separate hardwood and softwood plywood and veneer data not available prior to 1972.

[3] Pulpmills that are directly associated with other types of manufacturing facilities whose primary activity is not the production of woodpulp but some other product, such as paper, paperboard or building paper and board.

[4] Derived by dividing the value of shipments in current dollars by the Bureau of Labor Statistics producer price index of industrial commodities.

Source: See source note table 6.8.

While the primary timber processing industries have historically been composed of a relatively large number of firms, a trend toward larger and fewer firms is evident. In 1972, the four largest firms in the pulpmills industry (SIC 2611) produced 59 percent of the value of shipments, compared with 46 percent in 1958.[31] Similar changes have occurred in the other industries. However, the concentration of production is still fairly limited. About one-third of the value of shipments in the plywood and veneer industry is produced by the four largest firms. In the sawmill and planing mill sector, the four largest firms accounted for only 18 percent of the value of shipments.

Lumber Manufacturing

In 1972, there were nearly 23,000 establishments in the lumber manufacturing industry (table 6.8). There were about 284,000 people employed in the industry that year, and the value of the products shipped was $9.7 billion. In general, the number of establishments and employment in the industry declined between 1958 and 1976 (table 6.10). The value of shipments measured in constant 1972 dollars, however, rose from $5.3 billion in 1958 to $9.2 billion in 1976.

The number of logging establishments and the number of logging employees has changed little since 1958. Most of the change that has occurred has been in the sawmill and planing mill sector. The number of establishments in this sector decreased steadily from close to 17,000 in 1958, to a little over 9,000 in 1972. Employment dropped from 282,000 to 204,000 in 1972, but rose slightly to 208,000 in 1976. The value of shipments in constant 1972 dollars increased fairly rapidly, moving up from $4.2 billion in 1958 to $6.3 billion in 1976.

Over half of the Nation's lumber manufacturing (including logging) establishments in 1972 were in the South (table 6.11). These accounted for less than a third of the value of industry shipments. The Pacific Coast, where over 60 percent of the Nation's softwood sawtimber is located, had just under 4,000 establishments, but they produced nearly half of the industry's total value of shipments. The establishments on the Pacific Coast were, of course, relatively large, averaging more than 26 employees compared to an average of less than 10 in the North and South.

In 1976, about 36 billion board feet of lumber was produced by sawmills. The largest part of this volume, some 30 billion board feet, was softwoods. About 70 percent of this came from forests in the West, 26 percent from the South and 4 percent from the North. Hardwood lumber production — about 6.4 billion board feet — was nearly equally divided between the North and South. Only a negligible volume came from the West.

Plywood and Veneer Manufacturing

There were 598 establishments in the plywood and veneer industry in 1972 (table 6.10). Employment was 69,000 and the value of shipments $2.9 billion. The available data shows that both the number of establishments and number of employees in the plywood and veneer industry have not changed much since 1958. However, there have been large increases in the value of shipments measured in constant 1972 dollars, nearly all in the softwood veneer and plywood sector.

The 366 establishments producing hardwood plywood and veneer composed about two-thirds of those in the industry in 1972, but shipments and employment were largest in the softwood sector (table 6.10). In 1976, the establishments producing softwood plywood and veneer accounted for more than three-quarters of the value of shipments and two-thirds of the employment.

There were 200 hardwood plywood and veneer establishments in the South in 1972, with product shipments valued at $429 million (table 6.12). These numbers represent roughly half of all establishments and industry shipments. There were 114 plants in the North and 52 on the Pacific Coast. The Rocky Mountain region did not have hardwood plywood and veneer plants.

The Pacific Coast had 156 or 70 percent of the softwood plywood and veneer plants in the United States in 1972 and accounted for 70 percent of the value of shipments ($1.4 billion). The South had 57 plants which shipped products valued at $0.5 billion. The remaining establishments were in the Rocky Mountain region.

The concentration of the softwood plywood industry on the Pacific Coast reflects historical dependency on the large size, high-quality timber available from the old-growth forests of that region. In recent decades, technical developments have made it feasible to utilize the relatively small-size southern pine trees. As a result of this, lower stumpage costs, and proximity to the major plywood markets in the east, most of the growth in the softwood plywood industry since the mid-1960's has been in the South.

In 1976, softwood veneer log production from the southern pine forests was 3 billion board feet. Most of the remaining production — 5.2 billion board feet — came from the Douglas-fir forests of the Pacific

[31] *Ibid.*

Table 6.11 — *Characteristics of the primary timber processing industries in the United States, by industry, section, and region, 1972*

Section and region	Lumber manufacturing			Plywood and veneer manufacturing			Woodpulp manufacturing			Other primary timber manufacturing		
	Establish-ments	Employ-ees	Value of shipments	Establish-ments	Employ-ees	Value of shipments	Establish-ments	Employ-ees	Value of shipments	Establish-ments	Employ-ees	Value of shipments
	Number	*Thousand*	*Million dollars*	*Number*	*Thousand*	*Million dollars*	*Number*	*Thousand*	*Million dollars*	*Number*	*Thousand*	*Million dollars*
North												
Northeast	3,034	24.3	634.2	42	2.7	81.1	73	32.5	1,472.3	1,249	24.2	534.2
North Central	3,098	23.7	638.5	80	6.2	196.2	84	32.8	1,546.2	1,379	31.8	810.1
Total	6,132	48.0	1,272.7	122	8.9	277.3	157	65.3	3,018.5	2,628	56.0	1,344.3
South												
Southeast	6,353	48.8	1,326.7	160	12.9	455.7	56	34.2	2,118.0	599	19.7	482.4
South Central	5,182	61.9	1,731.8	97	11.6	474.3	69	39.9	2,392.6	705	25.8	658.0
Total	11,535	110.7	3,058.5	257	24.5	930.0	125	74.1	4,510.6	1,304	45.5	1,140.4
Rocky Mountains and Great Plains	1,102	23.0	813.9	13	2.3	105.4	3	2.2	153.6	112	1.2	37.5
Pacific Coast												
Pacific Northwest	2,990	74.3	3,275.7	173	29.4	1,444.5	39	17.5	1,095.4	175	6.0	213.2
Pacific Southwest	927	28.1	1,332.3	33	3.7	166.1	7	1.9	159.5	541	10.5	333.3
	3,917	102.4	4,608.0	206	33.1	1,610.6	46	19.4	1,254.9	716	16.5	546.5
United States	22,686	284.1	9,703.1	598	68.8	2,923.3	331	161.0	8,937.6	4,760	119.2	3,068.7

Source: See source note table 6.8.

Table 6.12. — *Characteristics of the plywood and veneer industry in the United States, by section, 1972*

Section	Number of establishments		Thousands of employees		Value of shipments in millions of dollars	
	Hardwood	Softwood	Hardwood	Softwood	Hardwood	Softwood
North	114	---	8.8	---	258.2	---
South	200	57	12.6	11.9	428.6	501.4
Rocky Mountains	---	11	---	2.2	---	104.5
Pacific Coast	52	156	4.0	29.2	225.0	1,386.6
United States	366	232	25.1	43.7	911.8	2,011.5

Source: See source note table 6.8.

Northwest. Hardwood veneer log production in 1976 amounted to 0.6 billion board feet. About two-thirds of this came from the South.

Woodpulp Manufacturing

There were 331 pulp mills in the United States in 1972 (table 6.8). This included 60 mills that produced market pulp and 271 mills that were integrated with paper, paperboard, building paper, and board mills. Employment, which included employees in the paper and board mills, was 161,000 or 25 percent of total employment in the primary timber processing industries. The combined value of shipments was almost $9 billion.

The softwood lumber and plywood industries are concentrated in the West, as is most of the inventory of softwood sawtimber.

The number of mills in the woodpulp industry in 1972 was slightly higher than in 1958 and substantially above the number reported in the early 1960's (table 6.10). Employment has trended up to the 160,000 level of 1976. The value of shipments in constant 1972 dollars has more than doubled, rising from $4.9 billion in 1958 to $10.5 billion in 1976.

Almost one-half of woodpulp manufacturing establishments reported in 1972 were in the North, but the average size was smaller than in the other geographic sections (table 6.11). More than one-half of the value shipments of the industry and nearly one-half of its employment was in the third of the establishments located in the South. Almost all of the remaining establishments were in the Pacific Coast section. The Rocky Mountain section had only three woodpulp mills.

Most of the growth in the woodpulp industry in recent decades has been in the South. This, in large part, has reflected a relatively favorable timber supply and cost situation. Pulpwood harvests (roundwood) from the forests in this section were 32 million cords in 1976. In addition to the roundwood, about 15 million cords of chips, largely obtained from the byproducts of sawmills and veneer plants, were used in the southern pulp industry in 1976. Total regional consumption amounted to 47 million cords or 65 percent of the wood consumed in United States pulpmills in that year.

The forests in the Pacific Coast section supplied about one-sixth of the wood used in the woodpulp industry in 1976. Most of this wood was chips obtained as byproducts from sawmills and veneer plants. The forests of the North supplied another 15 percent of the wood consumed, nearly all of it roundwood. The remaining 3 percent came from the forests in the Rocky Mountains.

Other Primary Timber Manufacturing

The other primary timber manufacturing industry includes plants making pallets, skids and particleboard; miscellaneous wood products such as lasts, ladders, and picture frames; turned and shaped wood products. It also includes wood preservation plants. In 1972, there were 4,760 establishments in the industry (table 6.8). Approximately 119,000 people were employed and the value of shipments was $3 billion.

There have been slow increases in the number of establishments and in employment in the other primary manufacturing industry in recent years (table 6.10). The value of shipments in constant 1972 dollars has increased from $1.5 billion in 1958 to $2.8 billion in 1976. However, growth in the value of shipments has varied greatly among the different types of plants on the industry. Shipments of products such as pallets and particleboard have shown rapid increases. Shipments of some other products have remained about the same or have declined.

The products of the other primary manufacturing industry are largely made from hardwoods; hence, most plants in the industry are located in the East. More than half of the establishments, employment, and value of shipments was in the North in 1972 and most of the remainder in the South (table 6.11). There were, however, 112 establishments in the Rocky Mountains and 716, or 15 percent of the total, on the Pacific Coast.

Domestic Timber Resources

Nearly all of the timber consumed in the primary processing industries comes from domestic forests. These forests are one of the most dominant cover types in the United States. As shown in the Forest and Range Land chapter (table 2.1), about 737 million acres — 33 percent of the Nation's land area — is classified as forest land.

Commercial Timberland

Nearly two-thirds of the forest land, or 482 million acres, is classified as commercial, that is, forest land capable of producing at least 20 cubic feet of industrial wood per acre per year and not reserved for uses which are not compatible with timber production. About 25 million acres of timberland — classified as productive reserved and deferred — meets the growth criteria for commercial timberland but has been set aside for parks, wilderness areas, or other uses. The remaining 230 million acres of forest land is incapable of producing a sustained crop of industrial wood. These lands are valuable for grazing, watershed protection, and recreation use, however, and are discussed in other chapters of this Assessment. In this chapter, only those acres classified as commercial timberland are considered.

Nearly three-quarters of the commercial timberland is located in the humid eastern half of the United States, where it is about equally divided between the North and South (table 6.13).[32] The commercial timberland in the West is concentrated in the Pacific Coast States of Oregon, Washington, and California, and in the Rocky Mountain States of Montana, Idaho, and Colorado.

There are 7 million acres of commercial timberland in Coastal Alaska and some 8 million acres in interior Alaska that may be classified as commercial timberland when forest surveys of the region are completed.

Seventy-two percent of all commercial timberland was privately owned in 1977. The remaining 28 percent was in Federal, State, and a variety of other public holdings.

Ownership of commercial timberland by Federal, State, or local governments reflects a variety of forces. Much of the National Forest System was reserved from the original Federal public domain to provide timber and other resources to meet the country's needs. Much of the State-owned forest land was obtained by the States as part of land grants from the Federal government on entry into statehood. Some forest lands were left in Federal ownership because they were unsuited for farming or other uses under laws that provided for transfer to private ownership. Still others were obtained by State or local government as tax-delinquent lands, especially during the 1930's.

Fourteen percent of the commercial timberland is owned by forest industry. The area in these ownerships has been increasing while that in other private ownerships has declined. Moreover, industry's stewardship now extends to substantial acreages of forest land that is under long-term lease from farmer and other private owners.

The remaining area of commercial timberland, some 278 million acres or 58 percent of the total, was in farmer and other private ownerships — a diverse group that includes housewives, doctors, lawyers, and numerous other occupations and retirees. A substantial number of these ownerships are small, some under 10 acres. At any given time, many owners have management objectives that are not compatible with

[32] Detailed statistics on forest area and timber volumes, growth, removals, and mortality by section, region, and State are contained in: U.S. Department of Agriculture, Forest Service. Forest Statistics of the U.S., 1977. 133 p. 1978.

Table 6.13 — *Area of commercial timberland in the United States, by ownership and section, January 1, 1977*

Ownership	Total, United States		North	South	Rocky Mountains and Great Plains	Pacific Coast[1]
	Area	Proportion				
	Thousand acres	*Percent*	*Thousand acres*	*Thousand acres*	*Thousand acres*	*Thousand acres*
Federal:						
National Forest	88,718,3	18.4	9,201,2	11,543.5	36,476.9	31,496.7
Bureau of Land Management	5,802.8	1.2	17.9	3.1	1,668.5	4,113.3
Other Federal	4,889.3	1.0	788.6	3,572.4	176.5	351.8
Total	99,410.4	20.6	10,007.7	15,119.0	38,321.9	35,961.8
State	23,415.3	4.9	12,832.3	2,594.7	2,235.0	5,753.3
County and municipal	6,834.1	1.4	5,605.4	727.3	76.8	424.6
Indian	6,061.8	1.3	855.6	184.9	2,849.7	2,171.6
Forest industry	68,782.2	14.2	17,658.4	36,500.1	2,095.5	12,528.2
Farmer	115,777.1	24.0	38,797.1	61,398.1	10,017.9	5,564.0
Other private	162,205.0	33.6	65,878.8	83,423.6	4,772.0	8,130.6
All ownerships	482,485.9	100.0	151,635.3	199,947.7	60,368.8	70,534.1

[1]Excludes some 18 million acres that may be classified as commercial timberland upon completion of forest surveys in interior Alaska.
Source: U.S. Department of Agriculture, Forest Service. *An analysis of the timber situation in the United States, 1952-2030.* (In process.)

timber harvesting. Part of the acreage in these ownerships is in heavily populated areas. While small size, management objectives, and location may constrain the potential for managing some of the area in these ownerships as production units, and at any given time limit the area available for harvest, all of these acres grow timber. Tenures are short and objectives change as owners change. The available evidence suggests that nearly all of the timber on these ownerships sooner or later becomes available and is used for industrial wood products or fuelwood.

Hardwood forest types made up of a plurality of such species as oak and hickory, gum, maple, birch, aspen, and other deciduous trees, occupied more than half of the commercial timberland area in 1977. More than two-fifths was occupied by the southern pines, Douglas-fir, hemlock, spruce, and other softwood species. The remainder, about 4 percent, does not contain tree cover adequate to determine forest type and is classified as nonstocked.

The area of commercial timberland rose from 409 million acres in 1952 to 509 million in 1962. The decline since then has been in response to land clearing for such things as cropland, pasture land, roads, and residential areas; reservation for other uses such as wilderness and parks; and a slowdown in the area of crop and pasture land reverting to forests.

Hardwood forest types occupy more than half of the Nation's commercial timberland.

Timber Inventory

The commercial timberlands of the United States contained some 792 billion cubic feet of roundwood in 1977 (table 6.14).

Size and species of timber. — About 64 percent of the total colume was in sawtimber trees (trees large enough to contain at least one log suitable for the manufacture of lubmer). Another 26 percent was in poletimber trees (trees from 5 inches in diameter at breast height to sawtimber size and now or prospectively suitable for industrial roundwood). The remaining 10 percent of all roundwood volume was in rough, rotten, and salvable dead trees. Some of this latter material may be suitable for lumber and veneer, but most of it is usable only for pulp, fuel, and other products where log quality requirements are flexible.

There are substantial volumes of fiber that are not included in the inventory statistics above. It has been estimated, for example, that about 40 percent of the total fiber in a tree occurs in the top, limbs, bark, and foliage.[33] In addition, nearly 25 percent of the total above ground fiber in the Nation's forests is in trees less than 5.0 inches diameter at breast height. Little use is being made of such material at the present time because it is not economically feasible with existing technology and with current costs of fiber from other sources. This material does, however, represent a large potential source of fiber for pulp, fuel, and the production of various petrochemical substitutes.

Softwoods predominate in the Nation's timber inventory, accounting for about 61 percent of the total volume of all classes of timber, and nearly two-thirds of the growing stock — poletimber and sawtimber trees. The softwood growing stock inventories are mostly on the Pacific Coast (table 6.15). This distribution, in constrast to that for commercial timberland, which is predominately in the eastern United States, reflects the concentration of timber in western old-growth stands where high volumes per acre are common.

National softwood growing stock inventories increased 7 percent from 1952 to 1977. Inventories in the North and South nearly doubled and there was a small increase in the Rocky Mountains. However, as a result of the harvest of old-growth stands there was a continuing decline, about 15 percent, on the Pacific Coast. National and regional softwood sawtimber inventories showed similar trends, although the changes on a percentage basis were somewhat smaller.

Hardwoods made up about 36 percent of all classes of standing timber in 1977, and about 23 percent of all sawtimber. More than 45 percent of all hardwood growing stock was in the North — nearly all the rest was in the South. The 255 billion cubic feet of hardwood growing stock in 1977 was slightly more than double that of 1952. Practically all of the increase took place in the eastern United States with the North and South making equal contributions.

Ownership of timber. — The largest portion of the softwood timber inventory in 1977 was in National Forests, including some 46 percent of all softwood growing stock and more than half of the softwood sawtimber (table 6.16). Most of this timber was in old-growth stands in the western United States, with

Table 6.14 — *Timber inventories on commercial timberlands in the United States, by class of material and species group, January 1, 1977*

Class of timber	All species		Softwoods			Hardwoods
	Volume	Proportion	Total	Eastern	Western	
	Million cubic feet	*Percent*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*	*Million cubic feet*
Growing stock trees:						
Sawtimber trees:						
Sawlog portion	452,786	57.1	341,904	82,017	259,887	110,882
Upper-stem portion	52,042	6.6	25,917	10,333	15,584	26,125
Total	504,828	63.7	367,821	92,350	275,471	137,007
Poletimber trees	206,140	26.0	87,958	49,217	38,741	118,182
Total	710,968	89.7	455,779	141,567	314,212	255,189
Salvable dead trees	14,114	1.8	13,197	278	12,919	917
Rough trees	44,042	5.6	7,396	4,552	2,844	36,646
Rotten trees	23,247	2.9	8,261	1,515	6,746	14,986
All classes	792,371	100.0	484,633	147,912	336,721	307,738

Source: See source note table 6.13.

Table 6.15 — *Growing stock and sawtimber inventories on commercial timberland in the United States, by section and softwoods and hardwoods, January 1, 1977*

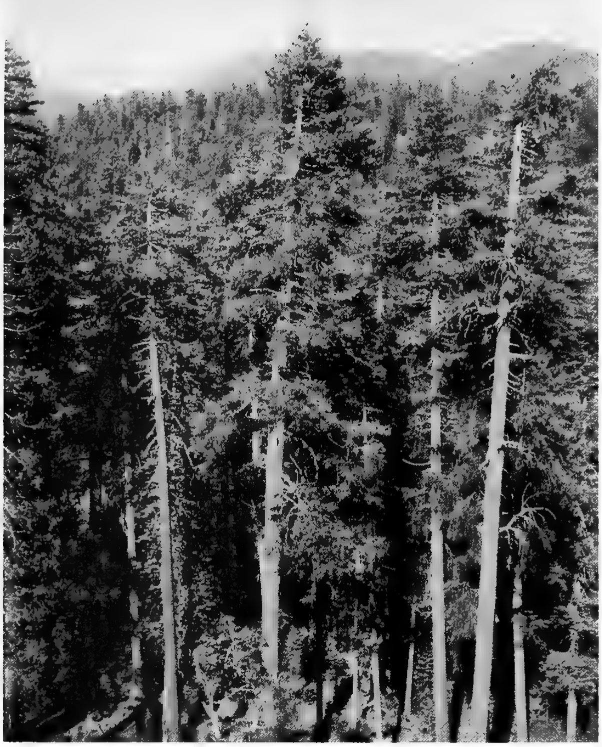
Section	All species		Softwoods		Hardwoods	
	Volume	Proportion	Volume	Proportion	Volume	Proportion
Growing Stock						
	Million cubic feet	*Percent*	*Million cubic feet*	*Percent*	*Million cubic feet*	*Percent*
North	159,759	22.5	43,515	9.5	116,244	45.6
South	213,977	30.1	98,052	21.5	115,925	45.4
Rocky Mountains and Great Plains	101,232	14.2	95,078	20.9	6,154	2.4
Pacific Coast	236,000	33.2	219,134	48.1	16,866	6.6
Total	710,968	100.0	455,779	100.0	255,189	100.0
Sawtimber						
	Million board feet[1]	*Percent*	*Million board feet*[1]	*Percent*	*Million board feet*[1]	*Percent*
North	325,400	12.6	93,835	4.7	231,565	39.0
South	643,650	25.0	343,114	17.3	300,536	50.6
Rocky Mountains and Great Plains	394,848	15.3	380,956	19.2	13,892	2.4
Pacific Coast	1,215,042	47.1	1,167,503	58.8	47,539	8.0
Total	2,578,940	100.0	1,985,408	100.0	593,532	100.0

[1] International 1/4-inch log rule.
Source: See source note table 6.13.

Table 6.16 — *Ownership of growing stock and sawtimber in the United States, by softwoods and hardwoods, January 1, 1977*

Ownership	Total		Softwoods		Hardwoods	
	Volume	Proportion	Volume	Proportion	Volume	Proportion
Growing stock						
	Million cubic feet	*Percent*	*Million cubic feet*	*Percent*	*Million cubic feet*	*Percent*
National Forest	228,449	32.1	207,698	45.6	20,751	8.1
Other public	75,503	10.6	50,946	11.2	24,557	9.6
Forest industry	106,266	15.0	74,382	16.3	31,884	12.5
Farmer and other private	300,750	42.3	122,753	26.9	177,997	69.8
Total, all ownerships	710,968	100.0	455,779	100.0	255,189	100.0
Sawtimber						
	Million board feet[1]	*Percent*	*Million board feet*[1]	*Percent*	*Million board feet*[1]	*Percent*
National Forest	1,058,386	41.0	1,009,287	50.8	49,099	8.3
Other public	286,099	11.1	235,174	11.9	50,925	8.6
Forest industry	394,924	15.3	314,276	15.8	80,648	13.6
Farmer and other private	839,531	32.6	426,671	21.5	412,860	69.5
Total, all ownerships	2,578,940	100.0	1,985,408	100.0	593,532	100.0

[1] International 1/4-inch log rule.
Source: See source note table 6.13.



Softwoods, mostly in old growth stands on the Pacific Coast, account for over three-fifths of timber inventories.

a major part in areas lacking access roads. National Forests contained only 8 percent of all hardwood growing stock.

Farmer and other private ownerships contained the major part of the Nation's inventory of hardwoods — about 70 percent — and a substantial part of all softwood inventories — about 27 percent. Nearly all of this timber is readily accessible from existing road systems and is favorably located in respect to the major timber-consuming centers.

Forest industries held 16 percent of all softwood inventories in 1977, and a somewhat smaller portion of hardwoods. Nearly all of this timber is accessible to primary timber processing plants.

Public agencies other than the Forest Service held roughly 11 percent of all timber inventories in 1977. Nearly all of these inventories are accessible and are important sources of timber for processing industries in the Pacific Northwest and the Lake States.

Timber Mortality

Annual mortality losses from natural causes — fire, insects, disease, storms, and other destructive agents — were estimated at about 4 billion cubic feet of growing stock in 1976 (table 6.17). Mortality of sawtimber amounted to an estimated 12 billion board feet (2.2 billion cubic feet). About 2.3 billion cubic feet of growing stock mortality and nearly three-quarters of sawtimber mortality was in softwood species.

There has been some decline in mortality in the last couple of decades. This has been entirely in softwood mortality and reflects the reduction in the area of old-growth stands, which have high natural mortality, in the Rocky Mountains and Pacific Coast. Hardwood mortality has shown some increases, a result of the build-up in inventories and the associated increase in stand crowding.

Most softwood mortality in 1976 was in the western United States, chiefly in the Pacific Coast section. This distribution is related to the concentration of timber volumes in this area and the high proportion of overmature timber characteristic of old-growth stands. Much of the sawtimber loss was in trees containing large proportions of high-quality material.

Timber mortality on the National Forests amounted to 1 billion cubic feet of growing stock, including 4.4 billion board feet of sawtimber. The bulk of this material was softwood. In fact, nearly half of the softwood sawtimber mortality occurred on the National Forests. The primary cause of death has been insect infestation and drought, mostly on the overmature trees in the old-growth stands.

While representing a significant volume — equivalent to slightly more than a third of the 1976 softwood removals from Forest Service lands — nearly all of the mortality on the National Forests occurs in areas which are unroaded and inaccessible for trucks and tractors. Moreover, much of the mortality is scattered over large acreages which precludes prompt detection and treatment. With the existing technology, the present location of processing plants, and current product prices, salvage of such mortality is not economically feasible in most forest stands including those in roaded areas.

Net Annual Timber Growth

Net annual growth (i.e., total annual gross growth less mortality) on growing stock was 22 billion cubic feet in 1976 (table 6.18). There were substantial volumes of growth in all regions and sections of the country. More than half of the growth was in the forest stands in the South. This is to be expected since most stands in that section are relatively young and vigorous. In the West, mortality in the old-growth stands offsets much of the total annual growth. As a result, net annual growth in the western sections was 5.2 billion cubic feet or less than 25 percent of the national total.

Table 6.17 — *Mortality of growing stock and sawtimber in the United States, by ownership and softwoods and hardwoods, 1976*

Ownership	Growing stock					
	Total		Softwoods		Hardwoods	
	Volume	Proportion	Volume	Proportion	Volume	Proportion
	Thousand cubic feet	*Percent*	*Thousand cubic feet*	*Percent*	*Thousand cubic feet*	*Percent*
National Forest	1,001,344	25.5	887,255	38.5	114,089	7.0
Other public	523,521	13.3	328,865	14.3	194,656	12.0
Forest industry	593,407	15.1	376,256	16.3	217,151	13.4
Farmer and other private	1,806,625	46.1	710,198	30.9	1,096,427	67.6
Total, all ownerships	3,924,897	100.0	2,302,574	100.0	1,622,323	100.0
	Sawtimber					
	Thousand board feet[1]	*Percent*	*Thousand board feet*[1]	*Percent*	*Thousand board feet*[1]	*Percent*
National Forest	4,349,450	35.7	4,104,285	46.8	245,165	7.2
Other public	1,771,725	14.5	1,404,470	16.0	367,255	10.7
Forest industry	1,856,043	15.2	1,353,759	15.5	502,284	14.7
Farmer and other private	4,210,872	34.6	1,902,325	21.7	2,308,547	67.4
Total, all ownerships	12,188,090	100.0	8,764,839	100.0	3,423,251	100.0

[1] International 1/4-inch log rule.
Source: See source note table 6.13.

Table 6.18 — *Net annual growth of growing stock and sawtimber in the United States, by ownership and softwoods and hardwoods, 1976*

Ownership	Growing stock					
	Total		Softwoods		Hardwoods	
	Volume	Proportion	Volume	Proportion	Volume	Proportion
	Thousand cubic feet	*Percent*	*Thousand cubic feet*	*Percent*	*Thousand cubic feet*	*Percent*
National Forest	3,116,303	14.4	2,465,499	20.1	650,804	6.9
Other public	1,957,220	9.0	1,077,789	8.8	879,431	9.4
Forest industry	4,072,978	18.8	2,866,307	23.3	1,206,671	12.9
Farmer and other private	12,517,815	57.8	5,875,146	47.8	6,642,669	70.8
Total, all ownerships	21,664,316	100.0	12,284,741	100.0	9,379,575	100.0
	Sawtimber					
	Thousand board feet[1]	*Percent*	*Thousand board feet*[1]	*Percent*	*Thousand board feet*[1]	*Percent*
National Forest	12,742,778	17.1	11,030,360	22.2	1,712,418	6.9
Other public	6,864,716	9.2	4,757,304	9.6	2,107,412	8.5
Forest industry	15,049,902	20.2	11,746,553	23.6	3,303,349	13.2
Farmer and other private	39,963,436	53.5	22,157,453	44.6	17,805,983	71.4
Total, all ownerships	74,620,832	100.0	49,691,670	100.0	24,929,162	100.0

[1] International 1/4-inch log rule.
Source: See source note table 6.13.

Well over half of the 1976 net growing stock increment was on softwood species. Again, more than half of this, as well as 48 percent of the net hardwood growth, was in the South.

Net annual sawtimber growth by species group showed the same regional patterns as growing stock. That is, about half of the total net annual sawtimber growth was in the South and well over half on softwoods.

Some 12.5 billion cubic feet or nearly 58 percent of the net annual growth in 1976 was on lands in farmer and other private ownerships. Moreover, this ownership accounted for nearly half of the net softwood growth and more than 70 percent of that of hardwoods.

Forest industry lands ranked next in importance —accounting for almost a fifth of the net growth. Another 3.1 billion cubic feet, most of which was softwoods, was on the National Forests. The other public ownerships accounted for the remaining 9 percent of the increment.

The distribution of net annual growth of sawtimber by ownership is approximately the same as that for growing stock.

Net annual growth of growing stock increased from 14 to 21.7 billion cubic feet between 1952 and 1976, a rise of 56 percent (table 6.19). Most of this increase was in the 14 years from 1962 to 1976. There were similar percentage increases for both softwoods and hardwoods. Sawtimber growth increased somewhat more rapidly, rising more than 63 percent in the 1952-76 period (table 6.20).

Net annual growth on a per acre basis also has been rising steadily on all ownerships and in all regions. Since 1952, the average per acre has increased from 28 to 45 cubic feet, a rise of 17 cubic feet or 61 percent. Farmer and other private ownerships showed the greatest improvement, with the average rising by

Table 6.19— *Net annual growth and removals of growing stock in the United States, by species group and section, 1976*

(Million cubic feet)

Item	All species				Softwoods				Hardwoods			
	1952	1962	1970	1976	1952	1962	1970	1976	1952	1962	1970	1976
North:												
Net growth	3,717	4,423	4,929	5,346	974	1,211	1,336	1,555	2,743	3,212	3,593	3,791
Removals	1,903	1,928	2,313	2,495	624	528	584	692	1,279	1,400	1,729	1,803
Ratio of growth to removals	2.0	2.3	2.1	2.1	1.6	2.3	2.3	2.2	2.1	2.3	2.1	2.1
South:												
Net growth	6,683	8,093	9,895	11,107	3,641	4,698	5,626	6,198	3,042	3,395	4,269	4,909
Removals	5,855	5,656	6,642	6,714	3,123	2,823	3,780	4,484	2,732	2,833	2,862	2,230
Ratio of growth to removals	1.1	1.4	1.5	1.7	1.2	1.7	1.5	1.4	1.1	1.2	1.5	2.2
Rocky Mountain and Great Plains:												
Net growth	1,187	1,357	1,573	1,733	1,100	1,257	1,454	1,594	87	100	119	139
Removals	568	760	911	867	534	738	890	843	34	22	21	24
Ratio of growth to removals	2.1	1.8	1.7	2.0	2.1	1.7	1.6	1.9	2.6	4.5	5.7	5.8
Pacific Coast:												
Net growth	2,326	2,820	3,362	3,478	1,969	2,377	2,823	2,937	357	443	539	541
Removals	3,536	3,615	4,182	4,153	3,489	3,534	4,065	4,027	47	81	117	126
Ratio of growth to removals	.7	.8	.8	.8	.6	.7	.7	.7	7.6	5.5	4.6	4.3
Total, United States:												
Net growth	13,913	16,693	19,759	21,664	7,684	9,543	11,239	12,284	6,229	7,150	8,520	9,380
Removals	11,862	11,959	14,048	14,229	7,770	7,623	9,319	10,046	4,092	4,336	4,729	4,183
Ratio of growth to removals	1.2	1.4	1.4	1.5	1.0	1.3	1.2	1.2	1.5	1.6	1.8	2.2

Note: Data for 1952 and 1962 differ from data published in earlier reports because of adjustments based on newer information from remeasured Forest Survey plots. Data for all years are "trend level" estimates.

Source: See source note table 6.13.

Table 6.20 — *Net annual growth and removals of sawtimber in the United States, by species group and section, 1976*

(Billion board feet, International 1/4-inch log rule)

Item	All species				Softwoods				Hardwoods			
	1952	1962	1970	1976	1952	1962	1970	1976	1952	1962	1970	1976
North:												
Net growth	8,126	10,068	11,567	12,637	2,261	2,832	3,401	3,955	5,865	7,236	8,166	8,682
Removals	5,462	5,663	7,812	1,762	1,390	1,976	2,184	3,700	4,273	4,273	5,836	5,511
Ratio of growth to removals	1.5	1.8	1.5	1.6	1.3	2.0	1.7	1.8	1.6	1.7	1.4	1.6
South:												
Net growth	22,295	27,421	33,119	38,550	13,699	18,050	21,212	24,266	8,596	9,371	11,907	14,284
Removals	20,996	19,059	23.823	27,623	11,931	10,937	14,934	18,975	9,065	8,122	8,889	8,288
Ratio of growth to removals	1.1	1.4	1.4	1.4	1.1	1.7	1.4	1.3	.9	1.2	1.3	1.7
Rocky Mountains and Great Plains:												
Net growth	4,396	4,789	5,390	6,756	4,181	4,560	5,119	6,361	215	229	271	395
Removals	3,312	4,389	5,076	4,935	3,186	4,290	4,985	4,831	126	99	91	104
Ratio of growth to removals	1.3	1.1	1.1	1.4	1.3	1.1	1.0	1.3	1.7	2.3	3.0	3.8
Pacific Coast:												
Net growth	11,069	12,892	16,165	16,678	10,029	11,534	14,540	15,110	1,040	1,358	1,625	1,568
Removals	22,466	22,356	25,636	25,284	22,299	22,089	25,245	24,858	167	267	391	426
Ratio of growth to removals	.5	.6	.6	.7	.4	.5	.6	.6	6.2	5.1	4.2	3.7
Total, United States:												
Net growth	45,886	55,170	66,241	74,621	30,170	36,976	44,272	49,692	15,716	18,194	21,969	24,929
Removals	52,236	51,467	62,347	65,177	39,178	38,706	47,140	50,848	13,058	12,761	15,207	14,329
Ratio of growth to removals	.9	1.1	1.1	1.1	.8	1.0	.9	1.0	1.2	1.4	1.4	1.7

Note: Data for 1952 and 1962 differ from data published in earlier reports because of adjustments based on newer information from remeasured Forest Survey plots. Data for all years are "trend level" estimates.

Source: See source note table 6.13.

17.7 cubic feet. This represents an increase of nearly two-thirds since 1952. The averages on the other public and forest industry ownerships rose by 16.8 and 16.0 cubic feet — 68 percent and 38 percent, respectively,

Net annual per acre growth on National Forests increased by 13.2 cubic feet in the 1952-76 period, a rise of 60 percent. At present, some 35 cubic feet are being produced annually on the average National Forest acre. This is below the other ownerships because of the inclusion of the old-growth stands in the West where mortality is high and net annual growth per acre is low. In the East, where stand and site characteristics are similar, net annual growth per acre on the National Forests is close to or above that of the other major ownerships.

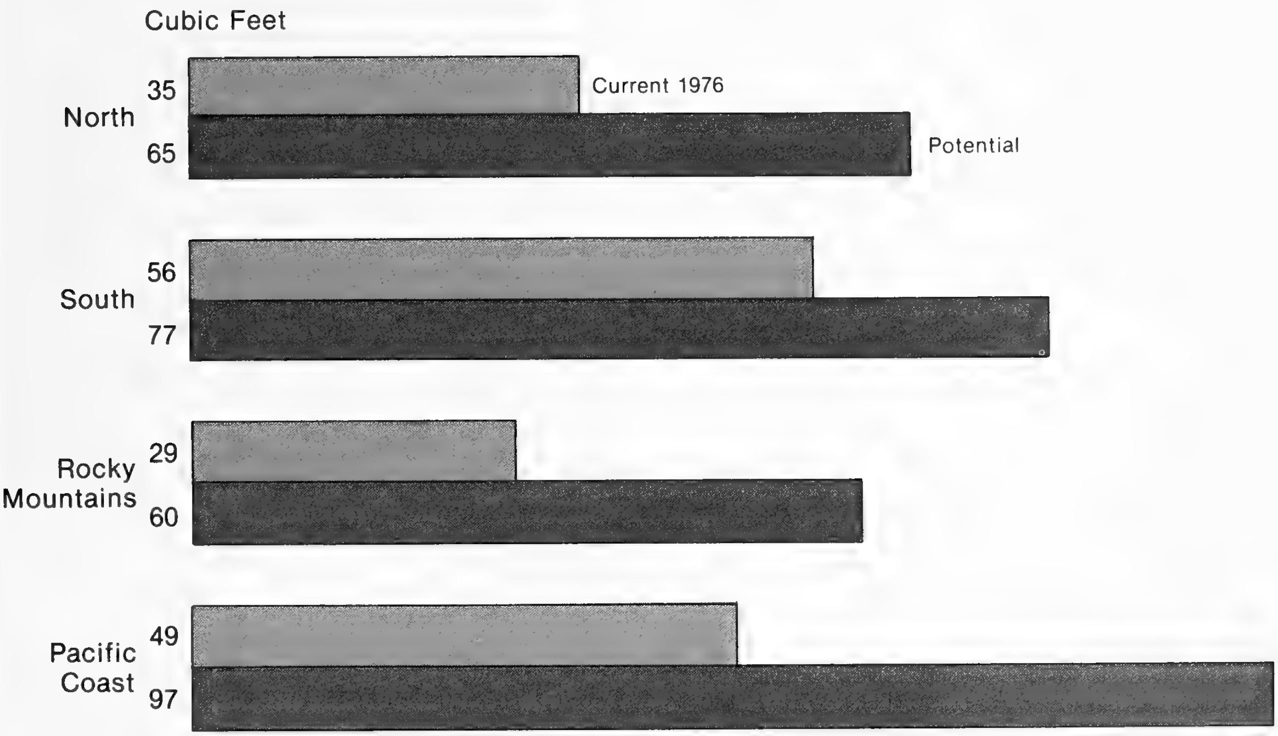
The rising trends in net annual timber growth illustrate a striking success story in American forestry. In the late 1800's and extending through the early decades of the 1900's, when the Nation's timber resources were being rapidly depleted, concern about future supplies led to the development of a broad array of policies and programs such as fire protection, tree planting, research, and public ownership. The large increases in net annual growth since 1952 are presumably a result of these policies and programs.

In spite of recent substantial increases, net growth per acre on all ownerships is only about three-fifths of what can be attained in fully stocked natural stands (table 6.21, fig. 6.3). Growth is far below what could be achieved with the use of genetically improved trees, fertilization, spacing control, and other intensive management measures.

The relatively limited net growth of growing stock and sawtimber in relation to the potential in 1976

Figure 6.3

Current and Potential Net Annual Growth Per Acre



reflects in part partial stocking of trees on much of the commercial timberland area, mortality and growth losses from destructive agents, and the presence of brush and cull trees that limit regeneration and increment of growing stock trees. These and other factors, such as restocking problems, often make it difficult and costly to achieve "full" stocking.

The gap between current average net annual growth per acre and potential growth per acre in fully stocked natural stands is substantial on all ownerships and in all regions. Thus, it appears that there is a lot of room for improvement. From the standpoint of increasing total timber supplies, the potential is largest on the farmer and other private ownerships that include 58 percent of the commercial timberland.

Timber Removals

Timber removals[34] in 1976 totaled more than 14 billion cubic feet of growing stock, including 65 billion board feet of sawtimber (tables 6.19 and 6.20). These volumes were substantially above levels in the 1950's and early 1960's, when removals averaged about 12 billion cubic feet of growing stock, including more than 50 billion board feet of sawtimber. Removals in 1976, however, are only slightly above 1970 levels. This reflects, in part, a relatively low level of demand for industrial timber products in 1976 resulting from the depressed situation in housing and nonresidential construction during that year.

Softwoods made up some 71 percent of all growing stock removals, and 78 percent of all sawtimber removals in 1976. These removals were concentrated in the Pacific Coast and South.

Nearly 36 percent of all softwood removals in 1976 came from farmer and other private ownerships. Another 36 percent came from forest industry ownerships, and about 28 percent from public lands.

By far the largest portion of timber removals is used for timber products. In 1976, 88 percent of all

[34] Timber removals from growing stock include: (a) Harvests of roundwood products such as sawlogs, veneer logs, and pulpwood; (b) logging residues; and (c) other removals resulting from noncommercial thinning and changes in land use such as clearing for cropland, highways, or housing development, and withdrawal of forest lands for parks or other nontimber uses.

softwood removals and 67 percent of all hardwood removals were used in this way. Total product use amounted to 11.8 billion cubic feet of roundwood, including 59 billion board feet of sawtimber. Logging residues accounted for most of the remaining removals.

Timber Growth-Removal Balances

Comparisons of net annual growth and removals shown in tables 6.19 and 6.20 provide an important indicator of the present timber situation including the physical availability of timber for harvest.[35]

Softwoods. — In the past two and one-half decades, net annual growth of softwoods in the eastern sections of the United States has been considerably higher than removals. For example, in 1976, net growth of eastern softwood growing stock exceeded removals by 2.6 billion cubic feet, or 50 percent.

Most of the excess of softwood growth over removals in the East was in the South. These generally favorable growth-removal balances indicate that eastern forests, and especially those in the South, can support larger softwood timber harvests. But large areas are still understocked, and a growth surplus will be needed for some time if inventories are to be built to more desirable levels. In addition, some part of the growth is on land held primarily for recreation or other nontimber purposes, and at any given time may not be available for harvest.

For the western United States, removals of softwood growing stock in 1976 exceeded net annual growth by 0.3 billion cubic feet, or 7 percent. Removals of softwood sawtimber totaled some 30 billion board feet, or nearly 8 billion board feet more than net annual growth.

These apparent imbalances in the West do not in themselves represent a serious problem on some ownerships and in some areas because a sizable part of the western timber harvest is drawn from old-growth stands where allowable harvest can exceed net growth for some time to come. Generally speaking, deficit cutting in the West is occurring on the Pacific Coast; the Rocky Mountain section is maintaining a favorable growth-removal balance.

Although it is not general, removals on the Pacific Coast, and particularly on forest industry ownerships, are at levels that cannot be sustained for long, given recent investments in management programs. As indicated in a following section, a substantial reduction in harvests is inevitable on these ownerships within the next decade or so.

[35] Many other factors such as species composition, volumes per acre, accessibility, size of trees, ownership objectives, and prices influence the volume of timber actually available for harvest.

In the last two and a half decades, net annual timber growth in eastern forests has been larger than removals, and inventories have been increasing.

Hardwoods. — Net growth of eastern hardwoods in 1976 substantially exceeded removals, particularly in the South. For the entire East, net growth of hardwood growing stock was 8.7 billion cubic feet — 116 percent above removals. Net growth of hardwood sawtimber was 22.9 billion board feet, 66 percent more than removals. Although overall growth-removal balances for hardwoods were generally favorable, in areas where extensive clearing has occurred — as along the river bottom lands in the West Gulf region in the South — net growth of hardwoods was less than removals.

Hardwood removals tend to be concentrated on preferred species such as walnut, sweetgum, yellow birch, and the larger diameter trees. As a result, removals were above or close to net annual growth for some species.

Projected Base Level Changes in Timber Resources

The current growth-removal balances show that domestic hardwood forests and eastern softwood forests can now support additional timber harvest. These balances will, of course, change; future supplies and particularly those in the last decades of the projection period can vary over a wide range. However, one of the objectives of this work is to prepare base level projections that will show the likely trends in

Table 6.21 —*Average net annual and potential growth per acre in the United States, by ownership and section, 1976*[1]

Item	Unit of measure	All ownerships	National Forest	Other public	Forest industry	Farmer and other private
North:						
Current	Cubic feet	35.3	42.6	36.4	44.0	32.9
Potential	Cubic feet	65.3	62.3	59.7	74.4	65.2
Current/potential	Percent	54.1	68.4	61.0	59.0	50.5
South:						
Current	Cubic feet	55.5	57.0	52.8	60.2	54.5
Potential	Cubic feet	77.3	71.1	71.0	83.3	76.5
Current/potential	Percent	71.8	80.2	74.4	72.3	71.1
Rocky Mountains and Great Plains:						
Current	Cubic feet	28.7	30.4	24.5	49.9	23.4
Potential	Cubic feet	59.5	63.7	54.5	74.1	49.7
Current/potential	Percent	48.2	47.7	50.0	67.3	47.0
Pacific Coast:						
Current	Cubic feet	49.3	30.3	53.1	79.3	62.0
Potential	Cubic feet	97.0	90.8	88.0	119.5	98.9
Current/potential	Percent	50.8	33.4	60.3	66.5	62.6
Total:						
Current	Cubic feet	44.9	35.1	41.6	59.2	45.0
Potential	Cubic feet	74.2	74.1	68.3	87.3	71.9
Current/potential	Percent	60.5	47.4	60.9	67.8	62.6

[1] Potential growth is defined as the average net growth attainable in fully stocked natural stands. Much higher growth rates can be attained in intensively managed stands.

Source: See source note table 6.13.

timber supplies and other measures of the timber resource such as inventories and net annual growth, if recent trends in the basic determinants continue during the next half century.[36] Specifically, these base level projections rest upon the assumptions that: (1) Radial growth and mortality rates during the late 1960's and early 1970's will continue, (2) commercial timberland area will continue to decline throughout the projection period to 446 million acres by 2030, (3) stumpage prices measured in 1967 dollars (net of inflation or deflation) will continue to increase in the future as they have in the 1960's and 1970's, (4) timber harvests (projected supplies) will respond to stumpage price and inventory changes much as they have during the base period from 1950-74, and (5) the current even-flow harvest policies and the nontimber management objectives on public lands will set ceilings, above which public harvests will not rise. Although not an explicit forest management assumption, the radial growth and mortality rates which are assumed to continue were greatly influenced by the forest management activity that occurred during the same time period.

In the simplest terms, the projections show what would happen to timber supplies if the trends in the major forces affecting the resource in the base period used in making the projections continue to 2030. Projections of the consequences of the continuation of recent trends are an essential first step in evaluating the need for changes in timber policies and programs.

This is the basic purpose of this analysis. There is no implication that the projected trends in timber supplies will continue during the next five decades. In fact, it is expected that as a result of the description of these trends, and the associated economic, social, and environmental implications, actions will be taken to change the trends in ways which are considered to be more desirable from the standpoint of the society.

Projected Base Level Timber Supplies

The base level timber supply projections prepared using these and related assumptions show the supply of softwood timber continuing to increase in the future, but at a slower rate than between 1962 and 1976. The increase is accompanied by a sizable shift

[36] The projections are derived from a computerized model which recursively simulates inventory changes and roundwood harvests. This model is described in appendix 4 of the report "An analysis of the timber situation in the United States, 1952-2030," *op cit.* This appendix also contains a brief discussion of other timber resource projection models and citations of the pertinent recent literature.

among the sources of softwood timber supplies by geographic section and ownership.

In total, projected softwood roundwood supplies rise from 9.6 billion cubic feet in 1976 to 12.3 billion cubic feet in 2030, an increase of 29 percent (table 6.22). The projected change in softwood sawtimber supplies over the same period is from 50.0 to 55.6 billion board feet, a rise of 11 percent (table 6.23, fig. 6.4).

Projected base level softwood supplies by section. — Roughly equal shares of the 1976 softwood roundwood supplies came from the South (45 percent) and Pacific Coast (41 percent). Together they accounted for 85 percent of the softwood roundwood supplies in the United States. The remaining 15 percent was about equally split between the North and the Rocky Mountains.

Base level softwood roundwood supplies in the South are projected to rise by 47 percent by 2030, from 4.2 billion cubic feet in 1976 to 6.2 billion. The majority of the increase comes from the farmer and other private lands. Large percentage increases also are projected for the North and Rocky Mountain sections, but these sections continue to be relatively small sources of supply.

In contrast to the projected increases in these sections, the softwood roundwood supplies are projected to drop in the Pacific Coast from 3.9 billion cubic feet in 1976 to 3.7 billion cubic feet in 2000. This is followed by a rise to 3.9 billion cubic feet in 2030. The major cause of the initial decline in the Pacific Coast is the inability of the forest industry lands to maintain current cutting levels. The old-growth inventory in this ownership class is rapidly being depleted and merchantable second-growth stands cannot offset the decline in supplies from old-growth stands. At the same time, supplies on the National Forest and other public ownerships increase, but they are constrained by evenflow and nontimber management objectives. National Forest projections are further influenced by expected withdrawals of commercial timberland for wilderness. Supplies from the farmer and other private owners in the Pacific Coast are also projected to increase, which is a reversal of a 25-year downward trend. The projected growth in supplies on National Forests, other public lands, and farmer and other private ownerships is not large enough to compensate for the drop on the forest industry ownerships.

The result of these divergent paths by section is a substantial shift in the importance of the major geographic sections as timber producing areas. The projected sectional shares of the softwood roundwood supplies in 2030 are 51 percent for the South and 31 percent for the Pacific Coast, quite different from the 45-41 percent shares in 1976.

In 1976, 50 percent of the softwood sawtimber came from the Pacific Coast and 36 percent from the South. The projected softwood sawtimber supplies in the Pacific Coast drops substantially, from 26.6 billion board feet in 1976 to 19.6 billion board feet in 2030, with much of the decline occurring by 1990. Softwood sawtimber supplies in the South are projected to increase from 18.0 to 27.3 billion board feet over the same period. By 2030, 49 percent of the softwood sawtimber supplies are projected to originate in the South and 35 percent in the Pacific Coast.

The young and growing pine forests of the South can support ncreased harvests.

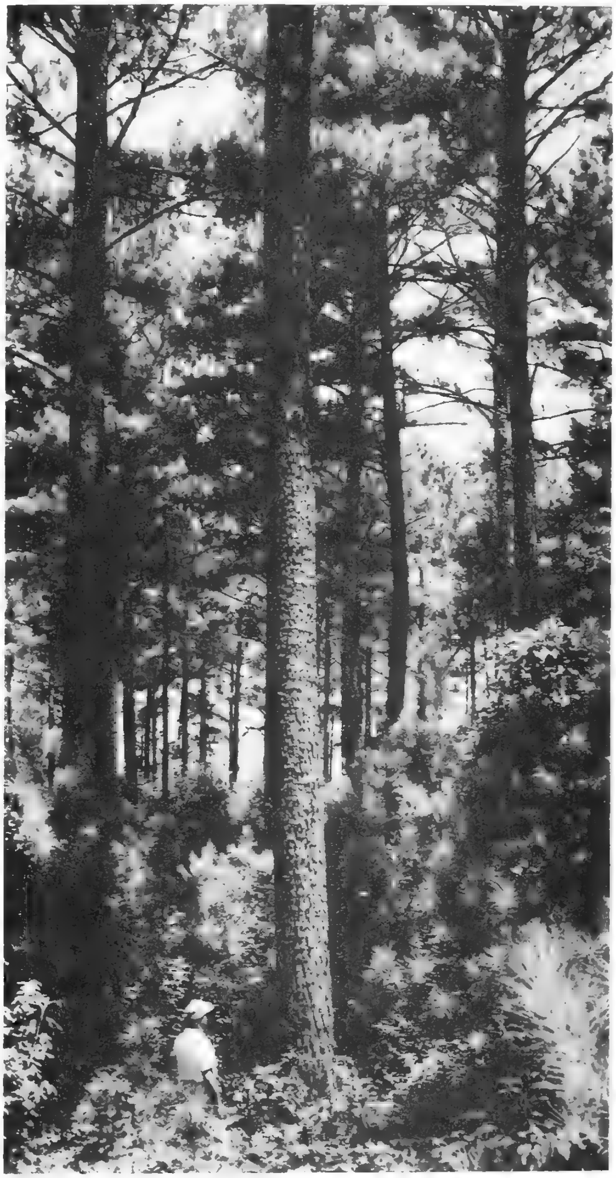


Table 6.22 — *Roundwood supplies, net annual growth, and growing stock inventory in the United States by section and softwoods and hardwoods, 1952, 1962, 1970 and 1976, with base level projections to 2030*

(Million cubic feet)

Item	1952	1962	1970	1976	Projections				
					1990	2000	2010	2020	2030
North:[1]									
Softwoods:									
Roundwood supplies	596	501	549	636	820	921	993	1,050	1,094
Net annual growth	993	1,234	1,362	1,600	1,722	1,660	1,554	1,452	1,374
Inventory	27,629	34,332	39,661	44,574	56,996	65,069	71,425	76,111	79,676
Hardwoods:									
Roundwood supplies	1,381	1,329	1,464	1,502	2,024	2,422	2,805	3,217	3,510
Net annual growth	2,992	3,507	3,926	4,192	4,305	3,963	3,623	3,386	3,282
Inventory	83,645	103,070	116,201	128,571	161,994	180,021	191,074	195,797	197,201
South:									
Softwoods:									
Roundwood supplies	3,049	2,709	3,531	4,234	4,887	5,392	5,774	6,053	6,229
Net annual growth	3,625	4,680	5,605	6,158	6,720	6,800	6,732	6,625	6,488
Inventory	58,245	71,553	84,896	97,136	119,833	134,699	145,385	152,465	156,120
Hardwoods:									
Roundwood supplies	1,935	1,648	1,833	1,692	2,732	3,466	4,117	4,773	5,213
Net annual growth	2,822	3,133	3,971	4,547	4,724	4,563	4,362	4,226	4,120
Inventory	78,238	84,485	91,923	104,873	130,525	142,820	146,839	144,123	135,550
Rocky Mountain:[1]									
Softwoods:									
Roundwood supplies	496	684	814	773	906	1,008	1,076	1,125	1,143
Net annual growth	1,097	1,253	1,449	1,589	1,629	1,607	1,557	1,493	1,427
Inventory	87,457	93,104	94,413	94,935	101,425	106,171	109,903	112,500	114,324
Hardwoods:									
Roundwood supplies	11	14	12	4	5	5	5	6	5
Net annual growth	57	66	84	100	98	96	94	91	87
Inventory	3,978	4,502	4,877	4,879	6,128	6,519	6,865	7,147	7,338
Pacific Coast:									
Softwoods:									
Roundwood supplies	3,395	3,435	3,807	3,868	3,757	3,737	3,763	3,807	3,868
Net annual growth	1,969	2,377	2,823	2,938	3,168	3,402	3,628	3,813	3,935
Inventory	251,614	241,833	230,820	219,134	190,267	184,276	181,837	181,237	182,132
Hardwoods:									
Roundwood supplies	35	61	82	97	126	134	137	136	133
Net annual growth	357	443	539	541	305	225	175	147	129
Inventory	12,586	14,904	17,636	16,866	16,989	17,518	17,603	17,440	17,219
Total, United States:									
Softwoods:									
Roundwood supplies	7,536	7,329	8,701	9,511	10,369	11,058	11,607	12,034	12,334
Net annual growth	7,684	9,543	11,239	12,285	13,240	13,470	13,472	13,382	13,224
Inventory	424,946	440,822	449,790	455,779	468,521	490,216	508,550	522,314	532,252
Hardwoods:									
Roundwood supplies	3,362	3,052	3,391	3,295	4,886	6,027	7,065	8,132	8,861
Net annual growth	6,229	7,149	8,519	9,380	9,431	8,846	8,253	7,850	7,618
Inventory	178,448	206,961	230,637	255,189	315,637	346,879	362,381	364,507	357,308

[1] Data for the Great Plains States — Kansas, Nebraska, North Dakota, and eastern South Dakota — included in the North.

Note: Supply data for 1952, 1962, 1970 and 1976 are estimates of the trend levels or harvests and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the volume that would be harvested given the assumptions of the study.

Inventory data for 1952 and 1962 are as of December 31. Data for 1970, 1977 and the projection years as of January 1.

Figure 6.4

Softwood Sawtimber Harvests, 1952 - 76, with Projections of Supplies to 2030

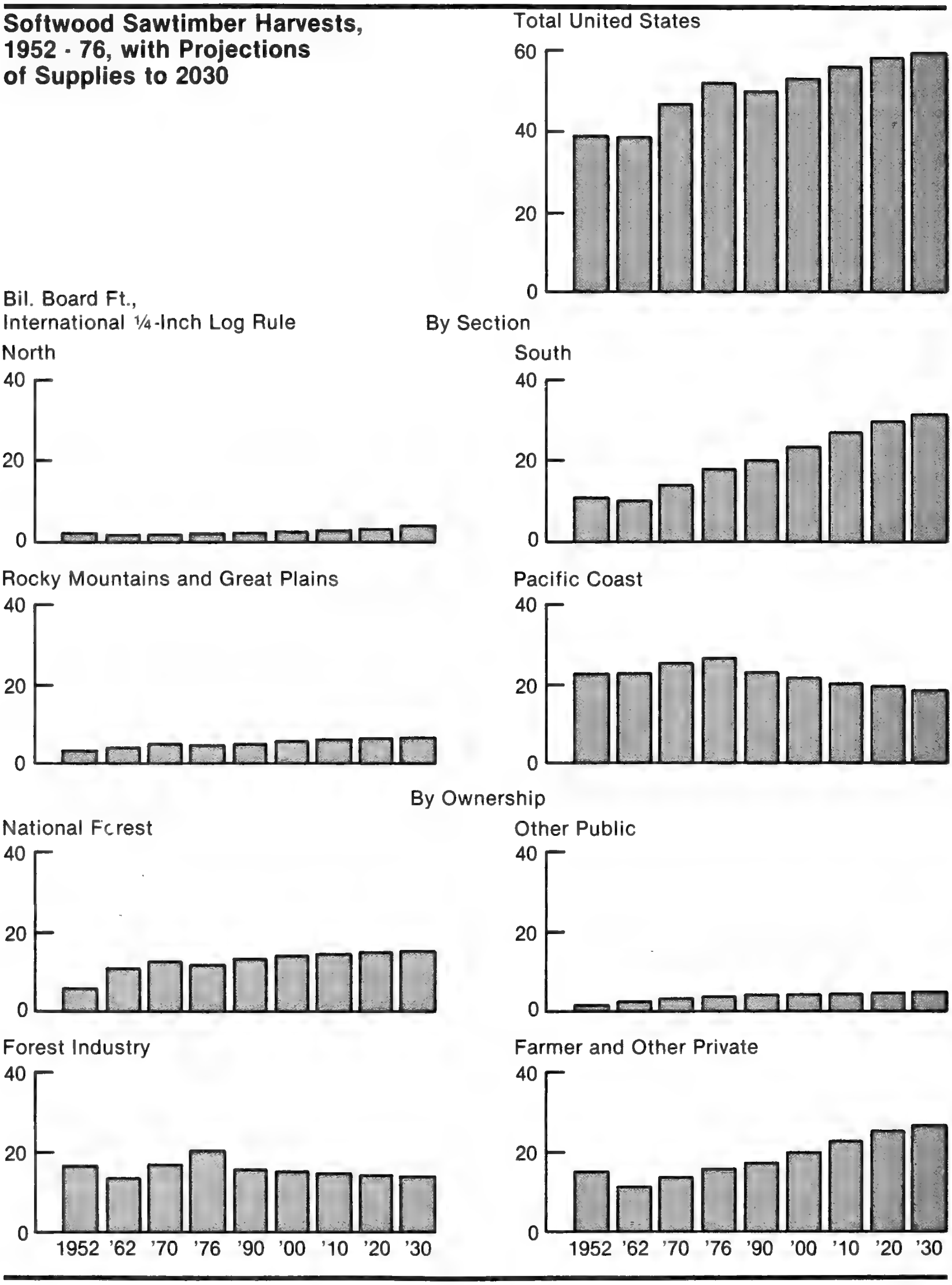


Table 6.23 — *Sawtimber supplies, net annual growth, and sawtimber inventory in the United States by ownership and softwoods and hardwoods, 1952, 1962, 1970 and 1976, with base level projections to 2030*

(Million board feet, International ¼-inch log rule)

Item	1952	1962	1970	1976	Projections				
					1990	2000	2010	2020	2030
North:[1]									
Softwoods:									
Sawtimber supplies	1,846	1,430	2,033	2,169	2,220	2,525	2,793	3,055	3,309
Net annual growth	2,337	2,920	3,498	4,077	4,237	4,579	4,845	5,041	5,197
Inventory	58,756	69,877	82,877	96,503	122,525	142,413	162,646	182,593	202,649
Hardwoods:									
Sawtimber supplies	4,090	4,413	5,861	6,188	5,480	6,549	7,603	8,807	9,674
Net annual growth	6,825	8,355	9,416	9,810	9,936	10,050	10,052	10,039	10,081
Inventory	189,873	212,277	236,784	262,517	326,105	363,247	391,946	410,969	424,684
South:									
Softwoods:									
Sawtimber supplies	11,342	10,275	14,225	17,985	19,404	21,867	24,068	25,933	27,327
Net annual growth	13,638	17,981	21,135	24,167	26,999	28,821	29,826	30,223	30,076
Inventory	196,556	245,712	295,804	341,022	427,160	495,310	555,193	604,146	638,275
Hardwoods:									
Sawtimber supplies	7,692	6,301	6,225	6,336	8,798	11,442	13,804	16,084	17,381
Net annual growth	7,754	8,374	10,785	13,296	15,292	15,591	15,269	14,669	13,732
Inventory	212,634	219,381	238,791	273,686	352,397	397,063	418,028	415,744	390,687
Rocky Mountain:[1]									
Softwoods:									
Sawtimber supplies	3,133	4,196	4,928	4,648	4,507	4,929	5,167	5,314	5,347
Net annual growth	4,166	4,541	5,098	6,337	6,407	6,697	6,845	6,865	6,815
Inventory	380,795	389,825	383,386	380,379	392,973	401,675	413,872	423,415	432,357
Hardwoods:									
Sawtimber supplies	15	19	12	17	14	19	20	22	22
Net annual growth	98	107	143	256	280	295	299	302	297
Inventory	8,983	9,633	9,964	9,790	12,341	12,855	13,481	14,028	14,541
Pacific Coast:									
Softwoods:									
Sawtimber supplies	22,421	22,241	24,912	25,152	21,983	21,134	20,489	19,959	19,567
Net annual growth	10,029	11,534	14,540	15,110	15,169	15,777	16,418	16,887	17,110
Inventory	1,430,096	1,327,344	1,239,606	1,167,503	978,446	911,742	864,954	830,138	805,466
Hardwoods:									
Sawtimber supplies	126	199	317	361	421	451	462	451	435
Net annual growth	1,040	1,358	1,625	1,568	937	673	508	399	330
Inventory	34,527	42,410	51,167	47,539	50,122	51,211	50,838	49,522	47,930
Total, United States:									
Softwoods:									
Sawtimber supplies	38,741	38,143	46,097	49,954	48,115	50,454	52,517	54,262	55,551
Net annual growth	30,170	36,976	44,272	49,692	52,812	55,875	57,935	59,016	59,197
Inventory	2,066,203	2,032,757	2,001,673	1,985,408	1,921,103	1,951,140	1,996,665	2,040,293	2,078,748
Hardwoods:									
Sawtimber supplies	11,924	10,933	12,414	12,902	14,713	18,460	21,889	25,365	27,513
Net annual growth	15,717	18,194	21,969	24,929	26,444	26,610	26,127	25,409	24,441
Inventory	446,018	483,700	536,706	593,532	740,964	824,376	874,293	890,263	877,842

[1]Data for the Great Plains States — Kansas, Nebraska, North Dakota, and eastern South Dakota — included in the North.

Note: Supply data for 1952, 1962, 1970 and 1976 are estimates of the trend levels of harvests and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the volume that would be harvested given the assumptions of the study.

Inventory data for 1952 and 1962 are as of December 31. Data for 1970, 1977 and the projection years as of January 1.

Changes in timber supplies of these magnitudes are certain to have major and long-lasting impacts on the economies of the two sections. From the standpoint of the Pacific Coast, it will mean closed mills and reduced timber-based employment and income. The impacts are likely to be particularly severe in rural areas where timber is the chief source of economic activity. In the South, on the other hand, it suggests new timber-based economic activity and associated increases in employment and income.

Projected base level softwood supplies by ownership. — The projected reduction in base level timber supplies on the Pacific Coast is mostly the result of a decline on forest industry lands. The projected increase in southern supplies comes largely from farmer and other private ownerships. Hence, the shift among ownerships is as marked as shifts among sections (tables 6.24 and 6.25).

In total, National Forest softwood roundwood supplies are projected to increase, in spite of an 11 percent reduction in commercial timberland area and the harvest ceilings imposed by the evenflow policy and nontimber management objectives, from 1.9 billion cubic feet in 1976 to 2.8 billion cubic feet in 2030, 22 percent of the national total. The softwood roundwood supplies from forest industry lands are projected to drop from 3.4 to 3.2 billion cubic feet between 1976 and 2000 and then to gradually climb to 3.3 billion cubic feet in 2030. This is 26 percent of the projected national total compared to the 36 percent contributed in 1976. The farmer and other private ownerships supplies of softwood roundwood are projected to increase from 3.4 billion cubic feet in 1976 to 5.2 billion cubic feet in 2030. The share of the total timber supply from these ownerships rises from 36 percent in 1976 to 43 percent in 2030.

The shifts in projected base level softwood sawtimber supplies among the ownerships are in the same directions as for softwood roundwood but generally larger. For example, the share from the farmer and other ownership increases from 29 to 41 percent of the total by 2030 while that on the forest industry drops from 38 percent to 24 percent.

Although the base level projections indicate that supplies will increase substantially on farmer and other private ownerships, mostly in the South, there is uncertainty about the future responsiveness of these ownerships to stumpage price and inventory changes. These ownerships were quite responsive to stumpage price increases between 1950 and 1974, but many have nontimber management objectives which could increasingly constrain harvests and raise harvesting costs.

Even more important from the longrun standpoint are the present limited investments in timber management. Maintaining or increasing softwood timber supplies in the South requires active timber management, especially the regeneration of softwood stands after harvest. Recent downward trends in the area in pine types in the south indicate this is not being done. As a result, there is a projected decline in net annual growth in the farmer and other private ownerships after 2000.

Projected base level hardwood supplies. — Hardwood timber harvests between 1952 and 1976 fluctuated around 3.3 billion cubic feet of roundwood and 12 billion board feet of sawtimber. Because of higher price elasticities, and the lack of any major inventory constraints upon harvesting, hardwood supplies are projected to increase at a faster rate than the softwood supplies. Hardwood roundwood supplies are projected to rise 2.7 times between 1976 and 2030, from 3.3 to 8.9 billion cubic feet. Sawtimber supplies more than double, moving up from 12.9 to 27.5 billion board feet.

The hardwood timber situation has been improving rapidly and further improvements are likely. By 2030 the hardwood forests can support harvests more than double those of 1976.

Table 6.24 — *Roundwood supplies, net annual growth, and growing stock inventory in the United States by ownership and softwoods and hardwoods, 1952, 1962, 1970 and 1976, with base level projections to 2030*

(Million cubic feet)

Item	1952	1962	1970	1976	Projections				
					1990	2000	2010	2020	2030
National Forests:									
Softwoods:									
Roundwood supplies	963	1,641	1,923	1,886	2,157	2,392	2,553	2,681	2,765
Net annual growth	1,663	1,999	2,361	2,465	2,710	2,871	2,986	3,057	3,073
Inventory	204,350	213,604	211,705	207,698	189,985	192,619	195,889	198,802	201,445
Hardwoods:									
Roundwood supplies	100	97	123	101	132	163	194	221	246
Net annual growth	396	508	569	651	631	560	484	433	397
Inventory	13,252	16,751	18,575	20,751	27,151	31,350	34,470	36,676	38,137
Other public:									
Softwoods:									
Roundwood supplies	416	562	706	805	908	948	991	1,026	1,060
Net annual growth	678	892	1,025	1,077	1,160	1,206	1,228	1,236	1,239
Inventory	49,918	49,533	50,421	50,946	54,315	56,721	59,212	61,609	63,885
Hardwoods:									
Roundwood supplies	122	115	156	177	232	271	307	339	367
Net annual growth	543	684	796	879	726	589	496	444	413
Inventory	14,645	18,805	21,930	24,557	29,978	33,904	36,331	37,866	38,783
Forest industry:									
Softwoods:									
Roundwood supplies	2,796	2,289	2,896	3,417	3,208	3,167	3,181	3,218	3,262
Net annual growth	1,872	2,326	2,611	2,866	3,084	3,200	3,249	3,267	3,270
Inventory	77,280	75,895	74,887	74,382	72,119	74,079	76,359	78,430	80,027
Hardwoods:									
Roundwood supplies	421	434	488	473	770	974	1,148	1,331	1,458
Net annual growth	688	830	1,058	1,207	1,254	1,237	1,204	1,187	1,176
Inventory	20,025	24,770	28,494	31,884	40,660	44,999	46,829	46,918	45,483
Farmer and other private:									
Softwoods:									
Roundwood supplies	3,361	2,836	3,177	3,403	4,097	4,551	4,883	5,109	5,247
Net annual growth	3,470	4,326	5,243	5,877	6,285	6,193	6,010	5,822	5,642
Inventory	93,398	101,790	112,777	122,753	152,103	166,797	177,091	183,473	186,895
Hardwoods:									
Roundwood supplies	2,718	2,405	2,624	2,543	3,752	4,618	5,416	6,240	6,789
Net annual growth	4,602	5,128	6,096	6,643	6,820	6,460	6,070	5,786	5,631
Inventory	130,526	146,635	161,638	177,997	217,848	236,626	244,750	243,047	234,905
Total, United States									
Softwoods:									
Roundwood supplies	7,536	7,328	8,702	9,512	10,369	11,058	11,607	12,034	12,334
Net annual growth	7,684	9,543	11,239	12,285	13,240	13,470	13,472	13,382	13,224
Inventory	424,946	440,822	449,790	455,779	468,521	490,216	508,550	522,314	532,252
Hardwoods:									
Roundwood supplies	3,362	3,052	3,391	3,295	4,886	6,027	7,065	8,132	8,861
Net annual growth	6,229	7,149	8,519	9,380	9,431	8,846	8,253	7,850	7,618
Inventory	178,448	206,961	230,637	255,189	315,637	346,879	362,381	364,507	357,308

Note: Supply data for 1952, 1962, 1970 and 1976 are estimates of the trend levels of harvests and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the volume that would be harvested given the assumptions of the study. Inventory data for 1952 and 1962 are as of December 31. Data for 1970, 1977 and the projection years as of January 1.

Table 6.25 — *Sawtimber supplies, net annual growth, and sawtimber inventory in the United States by ownership and softwoods and hardwoods, 1952, 1962, 1970 and 1976, with base level projections to 2030*

(Million board feet, International ¼-inch log rule)

Item	1952	1962	1970	1976	Projections				
					1990	2000	2010	2020	2030
National Forests:									
Softwoods:									
Sawtimber supplies	6,078	10,360	12,225	11,690	12,268	13,355	13,953	14,369	14,563
Net annual growth	6,915	8,154	10,175	11,030	11,859	12,915	13,739	14,278	14,504
Inventory	1,047,945	1,066,573	1,033,776	1,009,287	887,577	870,746	861,283	854,526	850,223
Hardwoods:									
Sawtimber supplies	343	339	442	478	372	487	609	728	842
Net annual growth	870	1,178	1,315	1,712	1,710	1,713	1,684	1,679	1,690
Inventory	30,683	37,884	42,140	49,099	64,664	76,222	86,513	95,535	103,399
Other public:									
Softwoods:									
Sawtimber supplies	2,326	3,322	4,297	4,971	4,777	4,833	4,957	5,049	5,143
Net annual growth	3,293	3,935	4,444	4,757	5,148	5,503	5,740	5,859	5,906
Inventory	254,771	240,564	236,372	235,174	240,645	245,421	253,008	261,919	271,435
Hardwoods:									
Sawtimber supplies	358	314	497	623	689	835	983	1,129	1,270
Net annual growth	1,123	1,575	1,845	2,107	1,941	1,904	1,885	1,880	1,867
Inventory	29,171	36,832	44,369	50,925	64,008	75,095	84,627	93,036	100,279
Forest industry:									
Softwoods:									
Sawtimber supplies	16,068	13,014	16,264	18,962	14,914	13,989	13,489	13,256	13,196
Net annual growth	7,962	9,396	10,675	11,747	11,908	12,405	12,802	13,100	13,269
Inventory	410,284	363,940	335,200	314,276	268,435	256,845	253,612	255,939	261,279
Hardwoods:									
Sawtimber supplies	1,463	1,530	1,663	1,791	2,484	3,204	3,799	4,381	4,705
Net annual growth	1,713	2,118	2,930	3,303	3,908	3,998	3,933	3,813	3,617
Inventory	52,749	61,131	73,206	80,648	105,169	117,861	123,200	122,664	116,566
Farmer and other private:									
Softwoods:									
Sawtimber supplies	14,268	11,447	13,311	14,332	16,155	18,278	20,118	21,588	22,650
Net annual growth	12,000	15,490	18,977	22,157	23,897	25,052	25,653	25,779	25,518
Inventory	353,203	361,680	396,324	426,671	524,446	578,129	628,763	667,910	695,811
Hardwoods:									
Sawtimber supplies	9,760	8,751	9,812	10,010	11,167	13,935	16,498	19,127	20,696
Net annual growth	12,011	13,323	15,880	17,806	18,886	18,995	18,626	18,037	17,267
Inventory	333,415	347,853	376,991	412,859	507,123	555,198	579,953	579,028	557,598
Total United States:									
Softwoods:									
Sawtimber supplies	38,741	38,143	46,097	49,954	48,115	50,454	52,517	54,262	55,551
Net annual growth	30,170	36,976	44,272	49,692	52,812	55,875	57,935	59,016	59,197
Inventory	2,066,203	2,032,757	2,001,673	1,985,408	1,921,103	1,951,140	1,996,665	2,040,293	2,078,748
Hardwoods:									
Sawtimber supplies	11,924	10,933	12,414	12,902	14,713	18,460	21,889	25,365	27,513
Net annual growth	15,717	18,194	21,969	24,929	26,444	26,610	26,127	25,409	24,441
Inventory	446,018	483,700	536,706	593,532	740,964	824,376	874,293	890,263	877,842

Note: Supply data for 1952, 1962, 1970 and 1976 are estimates of the trend levels of harvests and differ somewhat from the estimates of actual consumption shown in some tables. For the projection years, the data show the volume that would be harvested given the assumptions of the study.

Inventory data for 1952 and 1962 are as of December 31. Data for 1970, 1977 and the projection years are as of January 1.

Although less pronounced than the projected geographic shifts in softwood supplies, an increased share of the hardwood roundwood supplies is also projected to come from the South, from 51 percent in 1976 up to 59 percent (5.2 billion cubic feet) in 2030. The North's share shows a corresponding drop from 46 to 40 percent (3.5 billion cubic feet) in 2030. The shift in hardwood sawtimber supplies toward the South is greater than the shift in roundwood supplies. The cause of this geographic shift is a slower increase in supplies from the farmer and other private ownerships in the North. This presumably reflects differences in the importance of nontimber management objectives in the two sections. Overall, however, the farmer and other private ownerships are projected to continue to provide three-fourths of the hardwood supplies.

Projected Base Level Net Annual Timber Growth and Mortality

As described above, there have been substantial increases in net annual growth of both softwoods and hardwoods in all sections and regions and on all ownerships since 1952. In total, for example, net annual growth of softwood growing stock rose from 7.7 to 12.3 billion cubic feet, while that of hardwoods climbed from 6.2 to 9.4 billion cubic feet. Net annual growth of softwood sawtimber rose from 30.2 to 49.7, and hardwood from 15.7 to 24.9 billion board feet.

These trends are not expected to continue through the projection period. Net annual growth of softwood growing stock is projected to increase at progressively slower rates to 13.5 billion cubic feet in 2010 and decline slightly thereafter, to 13.2 billion cubic feet in 2030 (table 6.22). Net annual growth of softwood sawtimber follows a similar trend, but it is still increasing slowly beyond 2020 (table 6.23).

The projected trends in net annual softwood growth vary among sections and ownerships (tables 6.24 and 6.25). The trends for the North, South, and Rocky Mountain sections are similar to the national trends, although most of the decline that takes place in growing stock in the last decades of the projection period is in the South. Net annual softwood growth in the Pacific Coast section continues to increase through 2030. With respect to ownerships, net annual growth increases on the National Forests, other public, and forest industry ownerships — the decline takes place on the farmer and other private lands.

These trends have varying causes. The increases in the net annual growth on the Pacific Coast largely reflect the effects of replacing the old-growth forests on the National Forests and other public ownerships where net annual growth is low, with young forests where it is high. Net annual softwood sawtimber growth on the forest industry ownerships in this section declines through the projection period because of reductions in timber inventories.

Inventory accumulations to the point of overstocking are the cause of the declines in net annual growth on all ownerships in the North, on public lands in the South, and on most ownerships in the Rocky Mountains. Overstocking leads to a reduced gross growth and a slight increase in mortality, especially among small-diameter trees. As a result, net annual growth of growing stock turns down before that of sawtimber. The projected reduction in net annual growth in the South, nearly all on the farmer and other private ownerships, is largely caused by the reversion of large areas of harvested pine stands back to hardwoods. Overstocking is also a contributing factor.

The projected trends in net annual growth of hardwoods are roughly the same as those for softwoods. However, hardwood net annual growth peaks earlier and the decline is greater. Hardwood growing stock net annual growth shows a slight increase between 1976 and 1990 to 9.4 billion cubic feet but then drops to 7.6 billion cubic feet in 2030, 19 percent below the 1976 level. Net annual growth of hardwood sawtimber continues to increase for a longer period, but after a peak of 26.6 billion board feet in 2000, it drops to 24.4 billion board feet in 2030, slightly below the 1976 level of 24.9 billion board feet.

The general trends of hardwoods in the sections are similar to those shown by the national totals. There are some differences among ownerships — most of the drop occurs on the farmer and other private ownerships.

The peaking and subsequent decline in projected net annual growth of hardwoods is due to overstocking. Hardwood inventories simply cannot continue to increase without eventually having an adverse impact upon growth.

In response to overstocking, softwood growing stock mortality is projected to increase slightly in the future, rising from 2.3 billion cubic feet in 1976 to 2.9 billion cubic feet in 2030. This is a reversal of the downward trend in mortality between 1952 and 1976. Hardwood growing stock mortality is projected to continue its historical increase, also because of progressive overstocking, moving up from 1.6 billion cubic feet in 1976 to 2.4 billion cubic feet in 2030.

As a result of the influence of overstocking, a growing share of the projected mortality will come from natural stand development. As a timber stand matures and crown closure occurs, suppressed understory trees die. Because such trees are usually scat-

tered throughout the timber stand and are generally smaller in diameter than the live trees, they can seldom be economically harvested. This is especially true in rough terrain or where the nontimber impacts of harvesting impose costly harvesting techniques. There is some opportunity to salvage mortality which results from catastrophic loss, but even there the timber value decreases rapidly as the dead trees deteriorate.

Projected Base Level Timber Inventories

Timber inventories often are considered an indicator of the capability of the major ownerships to contribute to the Nation's timber supply. The potential to maintain or increase current harvest levels over the next three or four decades depends to a large extent on the present stock of timber. The intensity and character of forest management activities in the near future will have significant impacts on timber inventories and harvest levels beyond that time.

As indicated in the above discussion, the inventories of softwood growing stock increased slowly between 1952 and 1977, largely in response to accumulations of inventories in the North and South. Softwood sawtimber inventories declined slightly. This reflected the reduction in inventories in the Pacific Coast section associated with the harvests of old-growth stands. Softwood sawtimber inventories in the other sections increased, especially in the South, where they rose 59 percent.

The projections show increases in both softwood growing stock and sawtimber inventories (tables 6.22 and 6.23). Softwood growing stock inventories move up from 456 billion cubic feet in 1977 to 532 billion in 2030, a rise of 17 percent. Most of the increase takes place before 2010. Sawtimber inventories decline initially, then rise slowly to 2,079 billion board feet in 2030, a level about 5 percent above 1976.

As in the case of nearly all components of the timber resource, there are significant differences in softwood inventory trends among sections and ownerships (tables 6.24 and 6.25). Inventories of both growing stock and sawtimber rise very rapidly in the North and South. The increase is especially large in the South — sawtimber inventories in this section, for example, move up from 341 billion board feet in 1977 to 639 billion in 2030. There is also a small increase in the Rocky Mountain section. However, inventories in the Pacific Coast section decline, in the case of sawtimber, from 1,168 billion board feet in 1977 to 805 billion in 2030.

There are large increases in projected softwood inventories on farmer and other private ownerships. There are also small increases in growing stock inventories on the other major ownerships. In contrast, there are substantial decreases in the sawtimber inventories on the National Forest and forest industry ownerships. The reduction in the inventories in these ownerships is concentrated in the Pacific Coast section and is the result of the harvest of old-growth stands.

The trends outlined above have major impacts on the distribution of the softwood inventory by ownerships, as indicated in the tabulation below:

Ownership	*Ownership distribution of softwood sawtimber inventory (Percent)*	
	1976	*2030*
National Forests	50.8	40.9
Other public	11.8	13.1
Forest industry	15.8	12.6
Farmer and other private	21.5	33.5

Although the National Forests continue to have the largest softwood sawtimber inventory in 2030 (reflecting the volumes in residual old-growth stands), the National Forest share of the total drops markedly as does that for forest industry. The share in farmer and other private ownerships increases substantially. There is a related shift in timber volumes from the Pacific Coast to the South.

The hardwood growing stock inventory increased much more than the softwood inventory between 1952 and 1977, from 178.4 to 255.2 billion cubic feet. Hardwood sawtimber inventory also rose, although less rapidly, going up from 446.0 to 593.5 billion board feet.

The inventory of hardwood growing stock is projected to rise 40 percent by 2030 to 357.3 billion cubic feet, and hardwood sawtimber by 48 percent to 877.8 billion board feet. The rate of growth is considerably below the rate of accumulation in the 1952 to 1977 period. The slowdown is caused by reduced growth resulting from overstocking and increased timber removals.

Hardwood inventories — growing stock and sawtimber — increase in all sections except the Pacific Coast where the conversion of second-growth hardwood stands to softwoods is expected to result in some reduction. Inventories also rise on all ownerships with the largest part on the farmer and other private ownerships.

Unlike softwoods, the sectional distribution of the projected hardwood sawtimber inventories between the North and South is almost the same in 2030 as it was in 1977, each with a little less than half of the total. The ownership distribution is also about the same. The farmer and other ownerships continue to hold about two-thirds of the hardwood sawtimber inventories.

The Qualified Outlook

The above projections of timber supplies, net annual growth, and inventories should be considered only as indicative of what would occur if the assumptions on the basic determinants are realized. Many factors could cause changes in the projected trends. For example, more intensive management could lead to higher levels of timber growth and larger inventories. On the other hand, the levels could be lower as a result of larger shifts of commercial timberland to other uses, more constraints on timber management associated with the protection of the environment and multiple-use, or extraordinary mortality losses. Increases in the use of wood for fuel of the amounts being currently discussed by the people concerned with energy would have major impacts on timber resources and lead to a situation much different from that described, and especially for hardwoods.

Further, the projections are not intended as an indicator of what might be desirable from social, economic, or silvicultural standpoints — they are simply indicators of what is likely to happen if forests are cut and managed much as they have been in the last decade or so. The following analyses will show that, from the societal point of view, it will be desirable to change the outlook. The analyses also will describe two broad scope opportunities that could have a major impact on the supply outcome. First, there are vast biological opportunities for increasing timber supplies. A substantial part of these are economic opportunities, i.e., they would yield acceptable rates of return on investments. Second are opportunities to extend timber supplies through improvements in utilization including utilization of residues and wood fiber, such as in treetops and limbs, that are not included in timber inventories.

Projected Timber Demand-Supply Relationships

The base level projections of timber supplies discussed above and those of demand discussed earlier are summarized in tables 6.5 and 6.6.

The Demand-Supply-Price Outlook for Softwoods

The base level projections of demands on domestic forests for softwood roundwood — after allowances for imports and exports and improvements in utilization — rise from actual consumption of 9.2 billion cubic feet in 1976 to 13.8 billion by 2000 and 15.7 billion by 2030 (table 6.5, fig. 6.5). The base level projections of supplies of softwood roundwood from U.S. forests under the assumptions specified earlier show moderate increases from 9.2 billion cubic feet in 1976 to 11.1 billion in 2000 and 12.3 billion by 2030. The outlook for softwood sawtimber is similar — large increases in demand under base level assumptions and modest increases in supplies. The outlook is also similar by regions (table 6.26).

It is evident from these comparisons of the base level projections of demands and supplies that a substantial rise in the relative prices of softwood stumpage and most softwood timber products beyond the levels assumed in preparing the base level projections will be necessary to balance demand and supplies in future decades.

Projections of indexes of regional equilibrium softwood stumpage prices[37] are summarized in table 6.27. These projections show softwood stumpage prices rising substantially in all regions.[38] In the southern regions, stumpage prices measured in 1967 dollars and net of inflation or deflation, rise at an annual rate of 2.5 percent per year between 1976 and 2030.[39] This is considerably above the rate of increase in the Douglas-fir region of the Pacific Northwest (1.8 percent) and that in the northern regions (1.9 percent). It is, however, below those in the other

[37] These are prices necessary to bring about an equilibrium between the base level projections (medium level) of timber demands and supplies. These prices and the associated equilibrium timber demand-supply projections were developed by means of a regionally disaggregated economic simulation model. For further details see: Adams, Darius M., and Richard W. Haynes. The 1980 softwood timber assessment market model: structure, projections, and policy simulations. Pacific Northwest Forest and Range Exp. Sta., Portland, Oreg. (In process).

[38] The regional analysis includes assumptions about increasing processing efficiency but, like the base level price projections, does not include any assumptions regarding management intensification which would presumably result from the higher prices. To some extent, the prices projected in the last decades of the projection period are probably biased upward as higher stumpage prices should include management intensification that, after 2000, would lead to higher levels of timber supplies and lower prices. This "reiterative" or "loop" problem is addressed further in a following section of this chapter.

[39] All prices are measured in 1967 dollars, thus the effects of general price inflation or deflation are excluded. The increases shown therefore measure change relative to the general price level and to most competing materials.

regions and especially in the Rocky Mountain section where projected stumpage prices rise at an average rate of 3.8 percent per year. In all regions the rates of increase are largest in the first decade of the projection period — they progressively decline in the following decades.

The regional variations in the rates of increase are caused by a number of complex forces. In general, however, they reflect competition and differences in regional logging, manufacturing, and transportation costs. They are also influenced by the trend level of stumpage prices in 1976. When these 1976 prices are low (as is the Rocky Mountain section), the rates of growth will be much larger, even with the same dollar increase, than in regions in which the base year (1976) prices are high (as in the Douglas-fir region). Most of the decline in the rates of price increase over the projection decades is due to this same relationship, i.e. as prices move up, the rates of change drop, although the change in dollar terms may remain the same.

Table 6.26. — *Summary of softwood timber demand on, and supply from, forests in the contiguous States by region, 1952, 1962, 1970, and 1976 with projections (medium level demand) to 2030 under alternative price assumptions*

(Billion cubic feet)

Region	Item	1952[1]	1962[1]	1970[1]	1976[1]	Projections									
						Base level price trends[2]					Equilibrium price trends[3]				
						1990	2000	2010	2020	2030	1990	2000	2010	2020	2030
Northeast	Regional demand[4]	0.47	0.40	0.43	0.45	0.57	0.66	0.71	0.74	0.77	0.54	0.60	0.65	0.70	0.75
	Regional supply[5]	.47	.40	.43	.45	.53	.57	.61	.64	.67	.54	.60	.65	.70	.75
	Supply — demand balance	0	0	0	0	-.04	-.09	-.10	-.10	-.10	0	0	0	0	0
North Central[6]	Regional demand[4]	.21	.19	.16	.16	.35	.44	.49	.54	.57	.33	.39	.45	.51	.55
	Regional supply[5]	.21	.19	.16	.16	.29	.35	.38	.41	.43	.33	.39	.45	.51	.55
	Supply — demand balance	0	0	0	0	-.06	-.09	-.11	-.13	-.14	0	0	0	0	0
Southeast	Regional demand[4]	1.65	1.50	1.71	1.79	2.82	3.30	3.62	3.73	3.85	2.63	2.92	3.22	3.38	3.54
	Regional supply[5]	1.65	1.50	1.71	1.79	2.27	2.54	2.71	2.82	2.90	2.63	2.92	3.22	3.38	3.54
	Supply — demand balance	0	0	0	0	-.55	-.76	-.91	-.91	-.95	0	0	0	0	0
South Central	Regional demand[4]	1.27	1.11	2.09	2.30	3.30	3.83	4.23	4.40	4.52	2.97	3.23	3.55	3.71	3.83
	Regional supply[5]	1.27	1.11	2.09	2.30	2.64	2.88	3.05	3.21	3.31	2.97	3.23	3.55	3.71	3.83
	Supply — demand balance	0	0	0	0	-.66	-.95	-1.18	-1.19	-1.21	0	0	0	0	0
Rocky Mountain	Regional demand[4]	.42	.62	.86	.75	1.14	1.25	1.37	1.44	1.54	1.03	1.08	1.17	1.25	1.36
	Regional supply[5]	.42	.62	.86	.75	.91	1.01	1.08	1.12	1.13	1.03	1.08	1.17	1.25	1.36
	Supply — demand balance	0	0	0	0	-.23	-.24	-.29	-.32	-.41	0	0	0	0	0

See footnote at end of table.

Table 6.26. — *Summary of softwood timber demand on, and supply from, forests in the contiguous States by region, 1952, 1962, 1970, and 1976 with projections (medium level demand) to 2030 under alternative price assumptions — continued*

(Billion cubic feet)

Region	Item	1952[1]	1962[1]	1970[1]	1976[1]	Projections: Base level price trends[2] 1990	2000	2010	2020	2030	Equilibrium price trends[3] 1990	2000	2010	2020	2030
Pacific Northwest:[7] Douglas-fir subregion (western Washington and western Oregon)	Regional demand[4]	2.09	2.17	2.23	2.22	2.58	2.37	2.40	2.33	2.26	2.44	2.20	2.20	2.15	2.10
	Regional supply[5]	2.09	2.17	2.23	2.22	2.26	2.20	2.14	2.08	2.05	2.44	2.20	2.20	2.15	2.10
	Supply—demand balance	0	0	0	0	-.32	-.17	-.26	-.25	-.21	0	0	0	0	0
Ponderosa pine subregion (eastern Washington and eastern Oregon	Regional demand[4]	.33	.41	.56	.57	.65	.74	.83	.87	.92	.57	.61	.67	.71	.76
	Regional supply[5]	.33	.41	.56	.57	.54	.59	.63	.68	.72	.57	.61	.67	.71	.76
	Supply—demand balance	0	0	0	0	-.11	-.15	-.20	-.19	-.20	0	0	0	0	0
Pacific Southwest[8]	Regional demand[4]	.76	.83	.84	.85	1.00	1.02	1.05	1.05	1.06	.89	.87	.89	.89	.91
	Regional supply[5]	.76	.83	.84	.85	.77	.77	.80	.84	.88	.89	.87	.89	.89	.91
	Supply—demand balance	0	0	0	0	-.23	-.25	-.25	-.21	-.18	0	0	0	0	0
Total,	Demand[4]	7.20	7.23	8.88	9.09	12.41	13.61	14.70	15.10	15.49	11.40	11.90	12.80	13.30	13.80
	Supply[5]	7.20	7.23	8.88	9.09	10.21	10.91	11.40	11.80	12.09	11.40	11.90	12.80	13.30	13.80
	Supply—demand balance	0	0	0	0	-2.20	-2.70	-3.30	-3.30	-3.40	0	0	0	0	0

[1] Data are estimates of actual consumption or harvests and differ somewhat from the "trend" estimates shown in the preceding section on timber supplies.

[2] Projections show timber demand on, and supply from domestic forests assuming that the price trends in the base period used in making the projections (roughly from the late 1950's through the mid-1970's) continue through the projection period.

[3] Projections show timber demand on, and supply from domestic forests assuming that prices rise enough to maintain an equilibrium between projected demand and supply.

[4] Demand for products converted to a roundwood equivalent basis. The projections include adjustments for increased product yield per unit of roundwood input which are expected to result from improvements in utilization.

[5] The base level projections show the volume of timber available for harvest from regional forests if recent trends in the forces determining supply, such as commercial timberland area, management and prices, continue through the projection period.

[6] Includes the Great Plains States — Kansas, Nebraska, North Dakota and eastern South Dakota.

[7] Excludes Alaska.

[8] Excludes Hawaii.

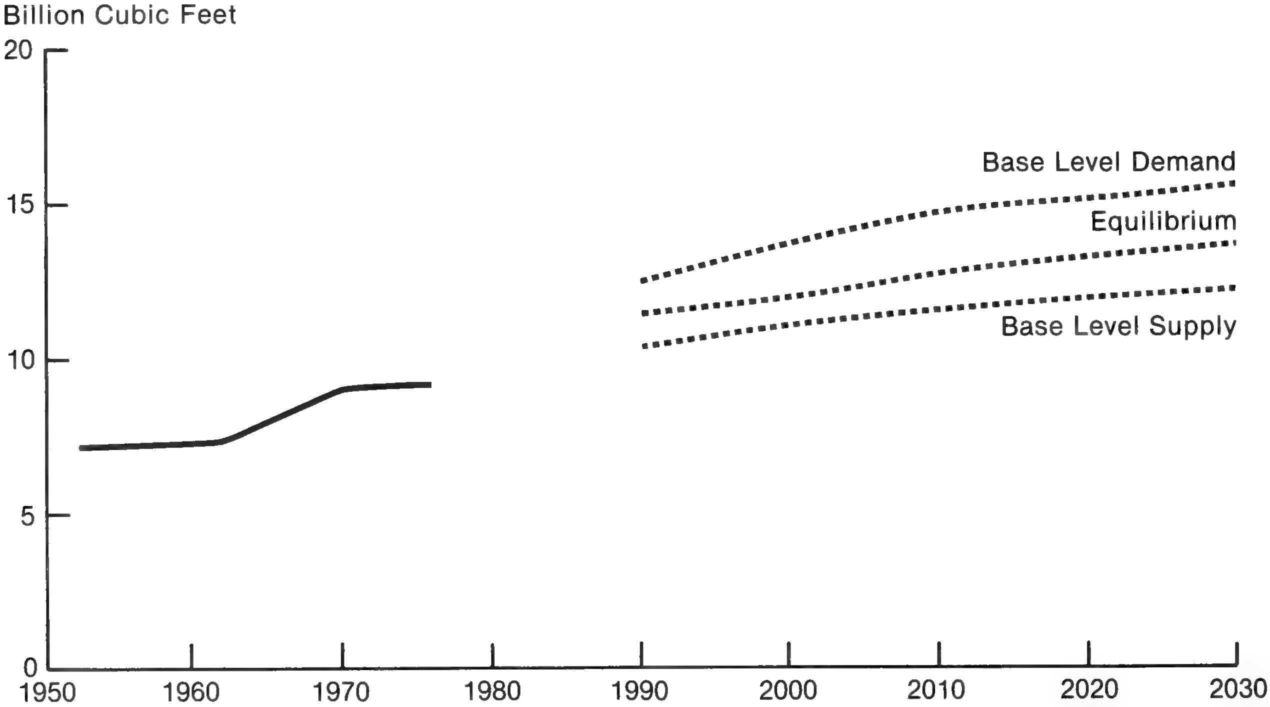
Note: Data may not add to totals because of rounding.

Sources: Data for 1952, 1962, 1970, and 1976 based on information published by the U.S. Departments of Agriculture and Commerce.

Projections: U.S. Department of Agriculture, Forest Service.

Figure 6.5

Projections of Softwood Roundwood Demands and Supplies on Domestic Forests



There are significant changes in demand and supplies associated with the projected increases in softwood stumpage prices. Roundwood demands are reduced below the amounts indicated by the base level projections in all regions (table 6.26). At the same time, supplies rise above the base level projections as private timber owners respond to higher prices. Consequently, as illustrated in figure 6.5, the equilibrium level falls between the base level demand and supply projections.

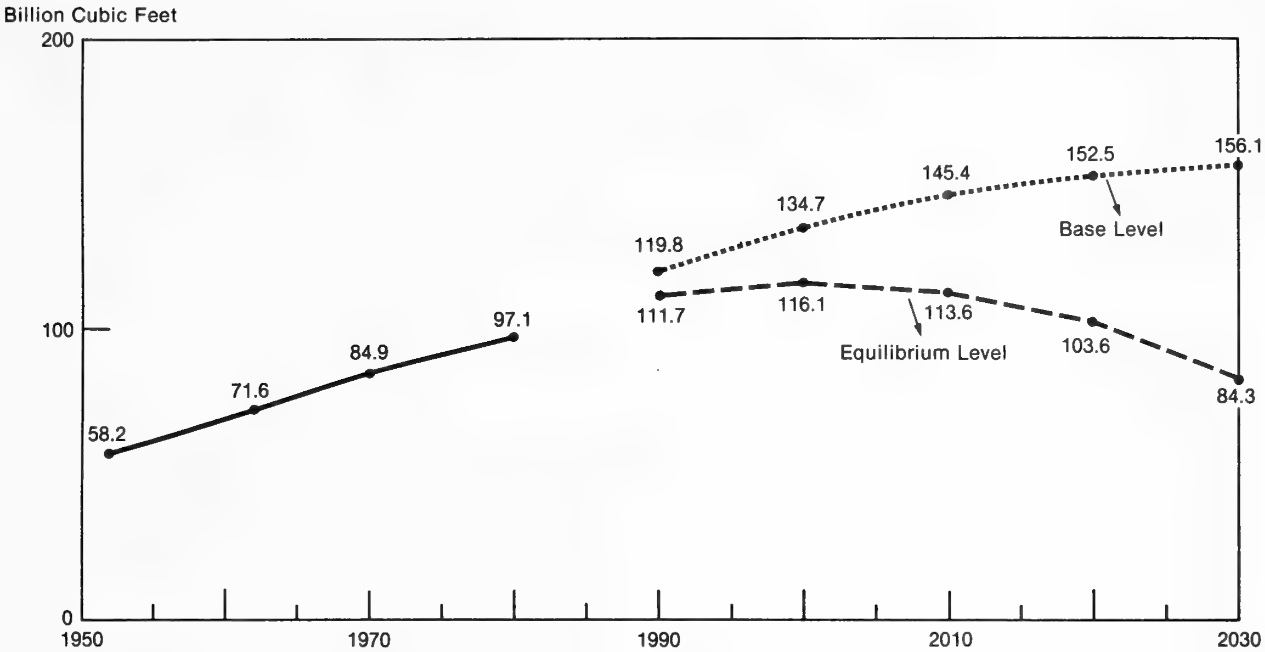
As a result of the increase in timber harvests associated with the equilibrium projections, by the end of the projection period softwood timber inventories in the South and the Pacific Coast would be substantially below those indicated for the base level projections shown in table 6.22. In the South, for example, the inventories of softwood growing stock in 2030 which would result from equilibrium levels of harvest are only a little over half of the projected base level inventories (fig. 6.6). Declines of this size mean that maintenance of the equilibrium levels of harvests for periods beyond the next few decades would require investments in various management programs much larger than assumed in the base level analysis. It also suggests that without greatly expanded management programs, prices in the latter part of the projection period, and in the decades that follow, are likely to rise at rates much above those indicated in table 6.27.

Equilibrium price paths for the major timber products also were developed by means of the regionally disaggregated economic simulation model (see footnote 37). This analysis shows softwood lumber and plywood prices measured in 1967 dollars, increasing at an annual rate of 1.7 and 1.4 percent, respectively. The lumber price increase is generally consistent with historical trends in relative lumber prices.

Equilibrium price increases for paper and board are likely to be lower than those for lumber, as in the past. For example, in contrast to the projected 123 percent increase for softwood lumber between 1976 and 2030, relative prices of paper and board rise by only about a third. This rise reflects the effects of

Figure 6.6

Projected Softwood Roundwood Inventories in the South



intensified competition for timber. However, greater increases in prices may be necessary in the pulp and paper industry to attract the capital required to meet projected demands for pulp and paper and to reflect rising costs of fossil fuels and chemicals.

The projected equilibrium stumpage price increases would have widely varying impacts on the base level projections of demand for the major timber products, because of differences in the price elasticity of demand and the importance of stumpage costs relative to product selling prices. The largest impact is on softwood lumber demands; the equilibrium projections show only a small increase over the levels prevailing in recent years and are much below the base level projections. On the other hand, the demand for paper, board, and pulpwood is not reduced very much — the projected equilibrium levels are close to the base level projections through the projection years.

The Demand-Supply-Price Outlook for Hardwoods

In the case of hardwood roundwood, projected base level demands on domestic forests — after allowances for imports and exports — rise from 2.9 billion cubic feet in 1976 to 6.0 billion in 2000 and 9.4 billion in 2030 (table 6.6). Projected supplies rise from 2.9 billion cubic feet in 1976 to 6.0 billion in 2000 and 8.9 billion in 2030. The supplies of hardwood roundwood potentially available under the base level assumptions in terms of cubic feet exceed or equal projected base level demands through 2000, but fall increasingly short thereafter. Demands on domestic forests for hardwood sawtimber rise from about 10.8 billion board feet in 1976 to 20.0 billion in 2000 and 29.7 billion in 2030. The projected demands are consistently somewhat above the base level projections of supplies throughout the projection period.

Table 6.27 — *Indexes of trend level[1] softwood stumpage prices[2] in the contiguous States, by regions, 1952, 1962, 1970, and 1976, with projections of equilibrium prices[3] to 2030.*

(Indexes of prices per thousand board feet, International 1/4-inch log rule — 1967 = 100)

Region	1952	1962	1970	1976	Projected indexes of equilibrium prices[3]				
					1990	2000	2010	2020	2030
Northeast	100.0	100.0	100.0	100.0	166.1	185.1	213.6	245.3	279.5
North Central	100.0	100.0	100.0	100.0	154.0	180.9	207.3	238.9	279.0
Southeast	57.8	83.3	111.6	138.9	229.6	280.0	358.0	434.6	526.8
South Central	57.8	83.3	111.6	138.9	230.6	281.6	358.5	434.3	524.7
Rocky Mountains	58.0	83.5	111.5	138.7	473.0	514.4	704.1	859.7	1045.0
Pacific Northwest:									
Douglas-fir subregion (Western Washington and western Oregon)	43.8	75.9	118.0	164.2	275.0	228.2	287.4	355.8	430.3
Ponderosa pine subregion (Eastern Washington and eastern Oregon)	80.6	93.1	104.4	113.8	300.5	330.6	425.1	500.8	603.1
Pacific Southwest	52.9	80.9	113.6	146.5	300.8	334.7	416.3	490.2	579.9

[1] Indexes of prices on a least squares regression line fitted to time series price data for the years 1950-76.

[2] Prices are measured in constant (1967) dollars and are net of inflation or deflation. They measure price changes relative to the general price level and most competing materials.

[3] Indexes of the prices which would result from stumpage prices rising enough to maintain an equilibrium between projected timber demands and supplies. These indexes were computed from stumpage price projections and the trend 1967 stumpage price. While convenient for displaying changes within regions and the relative rates of change between regions, these indexes should not be used to compare prices among regions. For example, the projected index levels imply that the Rocky Mountain region has the highest stumpage prices relative to other regions when in fact it is among those regions with the lowest stumpage prices.

The outlook by regions is somewhat different from the national outlook (table 6.28). Base level projected demands on domestic forests rise above base level supplies by 1990 in the South Central region but remain somewhat below base level supplies in the northern regions until after 2000.

In general, the base level projections for hardwood — both roundwood and sawtimber — show a more favorable supply outlook than is the case for softwoods. It appears that supplies will be adequate in the next two or three decades to meet demands for most hardwood products. As a result, there may not be much increase in average hardwood stumpage prices in the years immediately ahead (table 6.29). Beyond the next few decades, however, base level demands begin to rise above base level supplies. As this occurs, stumpage prices will move upward, especially in the South Central region, where the competition for the available supplies is likely to be the most intense.

This outlook will be changed if there is an increase in demand for fuelwood or any other product much above the projected levels. Such an increase would likely fall primarily on the hardwood resource in the North. A relatively small increase could significantly alter the demand-supply balances in the northern regions and result in rising prices in the years immediately ahead. A large increase in demand would, of course, greatly intensify the competition for hardwood timber and cause rapid increases in prices.

The immediate outlook for larger-sized hardwood sawtimber of preferred species, such as white oak, sweetgum, yellow birch, hard maple, walnut, and black cherry, is quite different from that for the smaller-sized lower-quality material. Removals of such timber have been close to or above net annual growth in recent decades, and continuing and large increases in stumpage prices have apparently reflected this situation. These trends seem likely to continue.

Partly as a result of these kinds of increases, and the smaller ones associated with the growth in demand for other kinds of hardwood timber, there is a substantial rise in projected prices of most hardwood timber products. These average about 1.2 percent per year for hardwood lumber and 0.7 percent per year for hardwood plywood.

The General Price Outlook

In view of the many uncertainties involved in projecting both demands and supplies, the above estimates of prices at which demands and supplies might be balanced must be regarded as general approxima-

Table 6.28—*Summary of hardwood timber demand on, and supply from, forests in the contiguous States by region, 1952, 1962, 1970, and 1976 with projections (medium level demand) to 2030 under alternative price assumptions*

(Billion cubic feet)

Region	Item	1952[1]	1962[1]	1970[1]	1976[1]	Projections									
						Base level price trends[2]					Equilibrium price trends[3]				
						1990	2000	2010	2020	2030	1990	2000	2010	2020	2030
Northeast	Regional demand[4]	0.55	0.55	0.54	0.52	0.73	0.88	1.03	1.17	1.30	0.72	0.85	0.98	1.13	1.22
	Regional supply[5]	.55	.55	.54	.52	.73	.88	1.01	1.14	1.24	.72	.85	.98	1.13	1.22
	Supply—demand balance	0	0	0	0	0	0	-.02	-.03	-.06	0	0	0	0	0
North Central[6]	Regional demand[4]	.98	.80	.75	.81	1.29	1.53	1.85	2.17	2.40	1.28	1.52	1.79	2.09	2.28
	Regional supply[5]	.98	.80	.75	.81	1.29	1.53	1.80	2.06	2.28	1.28	1.52	1.79	2.09	2.28
	Supply—demand balance	0	0	0	0	0	0	-.05	-.11	-.12	0	0	0	0	0
Southeast	Regional demand[4]	.77	.62	.63	.64	1.13	1.42	1.78	2.09	2.35	1.14	1.44	1.74	2.06	2.27
	Regional supply[5]	.77	.62	.63	.64	1.13	1.42	1.73	2.00	2.24	1.14	1.44	1.74	2.06	2.27
	Supply—demand balance	0	0	0	0	0	0	-.05	-.09	-.11	0	0	0	0	0
South Central	Regional demand[4]	1.27	.96	.89	.84	1.65	2.07	2.54	2.97	3.25	1.66	2.09	2.49	2.92	3.13
	Regional supply[5]	1.27	.96	.89	.84	1.62	2.02	2.41	2.75	3.00	1.66	2.09	2.49	2.92	3.13
	Supply—demand balance	0	0	0	0	-.03	-.05	-.13	-.22	-.25	0	0	0	0	0
West	Regional demand[4]	.03	.07	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
	Regional supply[5]	.03	.07	.09	.09	.13	.15	.15	.15	.14	.10	.10	.10	.10	.10
	Supply—demand supply	0	0	0	0	.03	.05	.05	.05	.04	0	0	0	0	0
Total, all regions	Demand[4]	3.60	3.00	2.90	2.90	4.90	6.00	7.30	8.50	9.40	4.90	6.00	7.10	8.30	9.00
	Supply[5]	3.60	3.00	2.90	2.90	4.90	6.00	7.10	8.10	8.90	4.90	6.00	7.10	8.30	9.00
	Supply—demand balance	0	0	0	0	0	0	-.20	-.40	-50	0	0	0	0	0

[1] Data are estimates of actual consumption or harvests and differ somewhat from the "trend" estimates shown in the preceding section on timber supplies.

[2] Projections show timber demand on, and supply from domestic forests assuming that the price trends in the base period used in making the projections (roughly from the late 1950's through the mid-1970's) continue through the projection period.

[3] Projections show timber demand on, and supply from domestic forests assuming that prices rise enough to maintain an equilibrium between projected demand and supply.

[4] Demand for products converted to a roundwood equivalent basis. The projections include adjustments for increased product yield per unit of roundwood input which are expected to result from improvements in utilization.

[5] The base level projections show the volume of timber available for harvest from regional forests if recent trends in the forces determining supply, such as commercial timberland area, management and prices continue through the projection period.

[6] Includes the Great Plains States—Kansas, Nebraska, North Dakota and eastern South Dakota.

Note: Data may not add to totals because of rounding.

Sources: Data for 1952, 1962, 1970, and 1976 based on information published by the U.S. Departments of Agriculture and Commerce.

Projections: U.S. Department of Agriculture, Forest Service.

Table 6.29. — *Indexes of trend level[1] hardwood stumpage prices[2] in the contiguous States, 1952, 1962, 1970, and 1976, with projections of indexes of equilibrium prices[3] to 2030*

(Index of price per thousand board feet, International 1/4-inch log rule — 1967 = 100)

Region	1952	1962	1970	1976	Projected equilibrium prices[3]				
					1990	2000	2010	2020	2030
Northeast	100.0	100.0	100.0	100.0	104.1	92.1	93.0	98.8	105.1
North Central	100.0	100.0	100.0	100.0	99.7	93.1	97.9	109.8	123.3
Southeast	100.0	100.0	100.0	100.0	113.9	99.1	101.7	112.9	126.4
South Central	100.0	100.0	100.0	100.0	136.3	123.6	137.3	166.9	203.0

[1] Prices on a least squares regression line fitted to time series price data for the years 1962-70.
[2] Prices are measured in constant (1967) dollars and are net of inflation or deflation. They measure price changes relative to the general price level and most competing materials.
[3] The prices which would result from stumpage prices rising enough to maintain an equilibrium between projected timber demands and supplies.

tions that would only be realized under the assumed conditions underlying these specific projections.

Many factors could lead to price paths different from those indicated by this analysis. For example, the projections of demand could vary from those shown if the growth in population, economic activity, and income is different from that assumed. As indicated above, changes in the demand for some products, such as fuelwood, also could greatly alter the future price outlook.

Timber supplies could be lower, and prices higher, than projected as a result of factors such as greater diversion of commercial timberlands to other uses, more constraints on timber management because of environmental considerations, nontimber objectives of forest owners, or extraordinary mortality losses. Also, more intensive management than that assumed could result in higher supply levels than shown by the projections and result in lower stumpage and product prices.

Despite all uncertainties, it does seem reasonably certain that the Nation is faced with the prospect of continuing and substantial increases in relative stumpage prices for most species and sizes of timber and for most timber products. The increases are likely to be largest for softwood sawtimber, the higher quality hardwood timber of preferred species, and the products — chiefly lumber and plywood — made from this timber. This outlook is consistent with the trends that have prevailed during most of the twentieth century. It reflects growing economic scarcity of a basic raw material.

Social, Economic, and Environmental Effects of Rising Timber Prices

A growing economic scarcity of timber and the associated increases in the relative prices of stumpage and timber products, such as those described above, will have significant effects on the economy, the environment, and general social well-being.[40] In general, future use of timber as defined by the demand-supply equilibrium analysis will be significantly below what it would have been if supplies were large enough to meet the base level projections of demand. The use of softwood sawtimber, for example, will be some 17 billion board feet less in 2030 than it would have been if supply was large enough to meet the projected demands.

Rising relative stumpage prices will, of course, benefit many stumpage owners, although the increase in returns per unit of stumpage sold may be offset in substantial part by reductions in the total volume sold. The timber processing industries, as distinct from stumpage owners, will experience reductions in future net revenues relative to what would have been received if stumpage supplies were large enough to meet base level demands. Further, it is estimated that rates of price increase for stumpage will be substantially higher than the rates for lumber and plywood. Thus, wood processors will be under considerable pressure to invest in new equipment and adopt manufacturing processes that reduce production costs and make more effective use of raw materials. Firms that are unable to make this adjustment will likely face serious difficulties.

Looked at in another way, the growing economic scarcity of timber will reduce markets and limit the expansion potential of the timber industries, particularly the lumber industry that is dependent on relatively large, higher-quality sawtimber. An indicator of this is the prospective effects on employment and

[40] For further amplification of the following material, see: McKillop, William. Social, economic, and environmental effects of rising timber prices. U.S. Department of Agriculture, Forest Service. (In process)

payrolls in the logging and timber processing industries. Employment per unit of lumber and plywood produced in the United States dropped quite sharply until the mid-1960's, but has leveled off since then.[41] Some slight further declines may occur as manufacturers install labor-saving equipment in an effort to hold down costs in the face of rising prices for raw materials. However, the absence of any significant current trend suggests that future levels of employment per unit of output may be close to those at the present time.

On this basis, it is estimated that the 17 billion board feet shortfall in softwood supplies referred to above would be associated with a level of timber industry employment in the year 2030 that is some 90,000 man-years less than would have existed if softwood timber supplies were large enough to meet base level projections of demand. Impacts on total economy-wide employment would be much larger because of the multiplier effect. Multiplier estimates derived by input-output analysis indicate that the associated total potential job losses in regional economies will be more than 250,000. Such impacts are especially critical because of the higher rates of unemployment frequently found in communities that are heavily dependent on timber or other natural resources.

Analysis of the relationship between lumber prices and construction cost[42] indicates that a 1.0 percent increase in the price of softwood lumber will lead to an 0.16 percent increase in the construction cost index of residences. Given estimates of the elasticity of demand for housing,[43,44] a 1.0 percent rise in the price of lumber will also lead to an 0.08 percent decrease in the number of housing units built.

The demand-supply equilibrium analysis presented above shows that softwood lumber prices will be some 82 percent higher in 2030 than the level in 1977. An increase of this size would result in a 7 percent reduction in output of residential units from the levels that would have existed with stable timber product prices. Increased substitution of competing materials might partially mitigate this impact, but the possibility of future rises in the relative prices of competing materials also must be considered, as must the costs of adapting building technology to utilize them.

Increases in consumer expenditures for timber products, or for commodities such as furniture made wholly or in part from them, is a major consequence of rising timber prices. The effect of rising timber prices will be partially offset by substitution of competing materials but, despite this, consumers will suffer substantial potential reductions in well-being. It is estimated that they will pay some $7 billion more for wood products and competing materials in 2030 because of the lack of sufficient softwood timber to maintain relative prices of processed wood at the 1977 level.

The effects of rising timber prices on the Nation's energy consumption and on environmental quality are also substantial. Materials such as steel, aluminum, concrete, and plastics that compete with wood products, are derived from nonrenewable resources. Greater energy requirements are necessary for utilizing nonrenewable resources than for timber resources;[45] and there are associated and serious problems of waste disposal and deteriorating environmental quality.[46] On the other hand, lumber and wood products are in a relatively favorable position because of recyclability, biodegradability, and the lower levels of air and water pollutants associated with their manufacture.[47]

The possibility of adverse environmental and energy impacts depends to a large extent on the degree to which substitute materials displace wood products as timber prices rise. Reports of the Committee on Renewable Resources for Industrial Materials provide information on the technical substitut ability of competing materials in residential construction.[48] This information suggests that 17 billion board feet loss in timber output would involve an increase of some 40 million tons in the use of concrete and some 20 million tons of steel. On the basis of the findings of a Committee panel, it was estimated that 17 billion board feet of softwood timber would require some 60 trillion British thermal units (Btu) of energy for its

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[41] Lumber and plywood production data from the U.S. Department of Agriculture, Forest Service. The demand and price situation for forest products. Miscellaneous Publication Series. Annual. Employment data from the U.S. Department of Commerce, Bureau of Economic Analysis. Survey of current business. Monthly.

[42] American Appraisal Company, Inc. Boeckh construction cost index for residences. *In* Construction Review. U.S. Department of Commerce, Industry and Trade Administration, Washington. Vol. 24, No. 8, p. 17. 1978.

[43] Reid, Margaret G. Housing and income. University of Chicago Press. Chicago. 405 p. 1962.

[44] Muth, Richard F. The demand for nonfarm housing. *In* The demand for durable goods. Arnold C. Harberger (Ed.), University of Chicago Press. Chicago. p. 29-96. 1960.

[45] Abelson, Philip H., and Allen H. Hammond. The new world of materials. Science, 101(4228) 633-636. 1976.

[46] Carpenter, Richard A. Tensions between materials and environmental quality. Science, 191(4228) 665-668. 1976.

[47] Cliff, Edward P. Timber: the renewable resource. Report to the National Commission on Materials Policy. Washington, D.C. 149 p. 1973.

[48] Committee on Renewable Resources for Industrial Materials. Renewable resources for industrial materials. National Research Council, Washington, D.C. 267 p. 1976.

extraction, processing, and transporta tion.[49] More than eight times this amount of energy would be required to produce the concrete and steel necessary to replace a like quantity of timber prod ucts in home construction.

Similar significant impacts may occur in relation to environmental quality as a result of substitution of competing materials for timber products. The production of these substitute materials results in substantially higher emissions of air and water pollutants. Implementation of air and water quality legislation will do much to lessen this pollution, but expenditures for controlling it represent substantial costs to society through higher prices, reduced output, or diversion of investment capital.[50,51] In addition, the greater energy demands of the steel, aluminum, concrete, and plastics industries means that any impairment of environmental quality is accentuated by potential pollution associated with increased power generation.

The impacts of substitution are not restricted to domestically produced materials. Imports of timber products, especially softwood lumber from Canada, can be expected to rise during the early decades of the projection period along with imports of substitute materials such as steel. Increased domestic production of energy-demanding substitutes will lead to greater importation of petroleum products. These changes, together with the possibility that exports of many products could be dampened by rising timber prices, means that the United States balances of trade could be significantly affected.

In summary, it seems that rising relative prices of stumpage and timber products will have far-reaching consequences of a diverse and complex nature. Consumer expenditures will increase, timber industry employment and output will decrease, environmental quality will be adversely affected, greater demands for energy will occur, and there may be a significant effect on the balance of payments. The President's Advisory Panel on Timber and the Environment concluded that "the long-term needs of the people and the Nation will be better served by increased production and improved use of timber rather than by increased reliance on nonrenewable minerals."[52] The low cost of wood is a major factor in its ability to compete with alternative materials. Restraining future rises in timber prices through increases in supply presents an opportunity to satisfy future demands for industrial materials at minimal cost to the individual citizen and to society.

[49] Boyd, C. W., P. Koch, H. B. Mckeen, C. R. Morschauser, S. B. Preston, and F. F. Wangaard. Wood for structural and architectural purposes. Report of CORRIM Panel II. *Wood and Fiber.* 8(1)1-72. 1976.

[50] Carpenter, Richard A. *op. cit.*

[51] LeSourd, D. A., M. E. Fogel, A. R. Schleicher, and T. E. Bingham. Comprehensive study of specific air pollution sources to assess the economic effects of air quality standards. Research Triangle Institute. Research Triangle Park. North Carolina. 76 p. 1970.

[52] President's Advisory Panel on Timber and the Environment. Arlington, Va. 541 p. April 30, 1973.

Biological and Research Opportunities for Increasing Timber Supplies and Reducing Losses

Future supplies of timber can be increased by a variety of measures such as accelerated regeneration; increased use of genetically improved planting stock; changing the species composition and the site conditions of some lands; improving the scheduling of harvest cuts and intermediate removals; reducing losses from natural mortality, fire, insects and diseases; and harmonizing the production of timber with other benefits.

Increasing Timber Supplies

Regeneration. — Much has been done to improve regeneration following logging. Site preparation and planting or seeding of stands and modification of harvesting practices to obtain natural regeneration are examples. For various reasons, the efforts have been inadequate, especially for softwood species. For example, hardwoods are replacing pine types in the South and brush on a number of softwood types in the West. Large increases in softwood timber supplies could result from regenerating these softwood stands after harvest. Shortening the regeneration period could also increase future supplies. The application of mycorrhizal fungi could reduce the time seedlings remain in nursery beds and improve seedling survival after outplanting.

In addition, softwood timber supplies can be increased by regenerating to conifers the nonstocked lands along the Pacific Coast. In northwestern California, western Oregon, western Washington, and coastal Alaska, more than 75 percent of the nonstocked lands are on highly productive sites. In contrast, most of the nonstocked commercial timberlands in other parts of the country offer relatively little opportunity to increase timber supplies, because the nonstocked site areas are concentrated on with low productivity.

In general, adequate hardwood regeneration naturally occurs after harvesting. However, harvesting practices that insure adequate openings and preserve soil fertility will greatly increase the growth and quality of the regenerated stands. Adequate hardwood

Rising prices of lumber, plywood and other timber products will have serious adverse impacts on consumers. For example, it will raise housing construction costs and reduce the number of units built.

regeneration often will require such measures as clearing; piling, chipping, disking, or burning logging debris; bedding prior to planting; controlling vegetation; or combinations of such measures.

Genetically improved planting stock. — Regeneration by planting offers an opportunity to use genetically improved planting stock. The possible increase in timber production per unit area may be as much as 15 to 20 percent. Breeding programs now underway could substantially expand these potential gains. For some sites, even larger increases can be attained with a joint use of genetically superior trees, fertilizers, and water controls.

The current trend toward tree selection and propagation of individuals with superior traits is designed to maximize yield, but tends to narrow the genetic base of the crop trees. This could lead to future disease and insect losses unless substantial effort is made to select for resistant lines and to monitor the wild population of pathogens to be aware of any new virulent biotypes that appear.

Stand and site conversion. — Many areas in the East and on the West Coast support poorly stocked stands, or stands stocked with less desirable species of poor quality trees that will produce little volume or value growth. Clearing of such stands and replanting can increase supplies of softwoods and certain preferred hardwood species. Also, in the case of some stagnated stands of species such as lodgepole pine in the Rocky Mountains, removal of the present trees and replacement by new stands of the same or different species is the only way to achieve full use of the site potential. Such conversion in some areas may be limited by low sites or because of wildlife or other nontimber considerations.

Some land areas such as the shrub bogs in the eastern United States, and some of the brushlands in the Pacific Northwest, can be changed to productive sites. Drainage, the addition of selected kinds of fertilizers, and an increase in physical accessibility for management actions are required to accomplish such changes.

Intermediate stand treatments. — In many forest types, stand density has increased to the point where long rotations are required to produce merchantable wood. At its worst, this crowding results in stagnation, especially on poor sites, with resulting stands of small, spindly trees that may never become merchantable — at least by present standards.

Intermediate treatments such as precommercial thinning, weeding, pruning, and release of desirable trees early in the life of overcrowded stands would have major impacts on timber values. Such treatments do not produce immediately usable wood, but have a payoff in faster growth of residual trees, shorter rotations, higher quality wood, and increased resistance to insects and disease.

There are large areas of overcrowded stands of merchantable size trees. Numerous research studies have indicated that cutting of some merchantable trees to improve spacing and stimulate growth (commercial thinning) can provide early returns, utilize material otherwise lost as mortality, and concentrate growth on the more valuable trees.

Accelerated harvest of old-growth stands on the National Forests in the West. — Increases in timber harvests above sustained yield levels in the old growth timber stands on the National Forests in the West could temporarily increase the volume of timber available for harvest. This course, which has been proposed by some members of the timber industries, some timber-dependent communities, and other associated interests, could offset for a time the expected decline in the harvest of timber from forest industry ownerships in the Pacific Northwest. However, harvests above the sustained yield level could not be maintained with present and planned management programs and the dependent industries and communities would sooner or later be faced with a drop in harvests. For this and other reasons, chiefly the impacts on the natural environment, accelerated harvest has been strongly opposed by environmental and preservation groups and many other nontimber groups interested in the management and use of the National Forests. Thus the rate of harvest on old-growth stands is a policy issue of wide interest — it is discussed further in an accompanying technical document, "A Recommended Renewable Resource Program" — 1980 update.[53]

Fertilization. — The use of fertilizers to accelerate and improve tree growth has been increasing in recent years. Most of this activity has been in the Pacific Northwest and in the South — practically all by industrial owners. Experience to date suggests that timber yields can be increased from 5 to 20 percent with applications of the proper fertilizers on nutrient deficient soils.

Large areas of naturally regenerated forests are overcrowded. This increases mortality and the time required to produce merchantable wood.

Drainage and irrigation are other enhancement actions that have been used in forestry for many years. On some sites, water control is the most important action for the establishment of trees for timber production.

Harvest practices. — Numerous studies have shown that an important way to increase future timber growth is to use harvest practices that return the leaves and small branches to the soil. This material contains relatively large amounts of nutrients that support the next generation of trees. In addition, this material reduces surface erosion and contributes to maintaining soil structure. Harvest practices should also be designed to minimize damage to residual trees and reduce the volume of unmerchantable tops of trees and defective trees left on the ground as logging residues.

Research. — Much can be done to increase timber growth through more effective use of existing technology. Investments in intensified management could be made more effective by expanding the technological base for such efforts. More information is needed about the responses of forest stands of different types, ages, and sites to intermediate treatments such as thinning. Better knowledge of spacing control in precommercial thinning and subsequent intermediate cutting could help increase output of both timber and nontimber values. Before the most effective tree fertilization can be achieved, more knowledge must be

[53] U.S. Department of Agriculture. Forest Service. A recommended renewable resources program — 1980 update. For Serv. Series FS-346. 540 p. plus appendixes. 1980.

obtained on the response of trees on various soils, and the effects of fertilizers on the environment. Research on genetic improvements in timber growing should include better methods of progeny testing to detect natural resistance to insects and diseases.

There are substantial areas where planting costs are high. The development of lower cost techniques for site preparation and planting for such areas would improve returns from forest investments. In many forest types, development of more effective methods of timber harvesting, to bring about natural regeneration of desirable timber species, is of key significance in assuring prompt and low-cost establishment of new stands and the protection of esthetic or other nontimber values. Improvement of aerial logging techniques using skyline systems could increase timber harvests as well as enhance environmental values.

Reducing Losses

Reduction of mortality from poor harvesting practices, wildfire, insects, and diseases can increase net annual growth. Research can reduce losses by developing more effective preventive and control techniques and better understanding of fire effects.

Effective fire management. — The largest and most effective management effort in the United States has been in the control of forest fires. The results have been remarkable, with a decline in area burned from 30 to 40 million acres annually at the beginning of the century to about 5 million acres annually in the mid-1970's.

Despite the progress that has taken place, there appear to be additional opportunities to further reduce fire losses and costs through development and use of improved technology in fire prevention, detection, suppression, presuppression, and fuels management. These opportunities include developing a better understanding of ways to prevent fires, improving detection systems, and the development of techniques for more effective control of fires. Improved fire suppression systems, particularly on large fires that characteristically result in greatest fire damage, could also reduce losses.

Fire losses might also be cut by reducing fuel accumulation on cutover areas through the development of markets for logging residues and/or improved cleanup of cutover areas. Future improvement of techniques for use of prescribed fire to reduce the build up of flammable debris and litter also could help reduce the intensity of wildfires and attendant losses. There is a related need for research on ways of dispersing and/or minimizing smoke from prescribed fires to meet acceptable air quality standards.

Better control of insects and diseases. — Insects and diseases take a heavy toll of timber by killing trees and by reducing timber growth. Serious losses are caused by a few major pest species such as the western bark beetles, southern pine beetle, spruce budworm, gypsy moth, dwarf mistletoes, and root rots which account for most of the mortality. Other insects and diseases cause serious but less spectacular damage by killing shoots and terminals, reducing the rate of growth, or by stunting, deforming, or degrading the value of trees and wood products.

The use of integrated pest management systems against the major forest pests offers the potential to increase or extend the timber supply in an environmentally acceptable manner. Elements of management systems that could reduce insect- and disease-caused losses include: (1) Silvicultural techniques that encourage more pest resistant stands; (2) improved methods of pest control with biological control agents; (3) selective chemical pesticides which are safe and environmentally acceptable; and (4) stand hazard rating systems that identify pest-susceptible trees and stands.

Economic Opportunities for Increasing Timber Supplies

The preceding discussion has been concerned with biological opportunities for increasing timber supplies without consideration of costs and returns. With expected changes in management costs and product prices, only part of the biological opportunities can be expected to yield an acceptable rate of return on the investments required to put the opportunities into practice. An ongoing study of the Forest Service and the Forest Industries Council[54] indicates that the opportunities that would yield 4 percent or more on the investment, measured in constant dollars, are large and, if carried out, would in time increase timber supplies in a major way.

Results from the study show that there are economic opportunities for treatment on 168 million acres of commercial timberland — some 35 percent of the Nation's total (table 6.30). With treatment of these acres, net annual timber growth could be increased by 12.9 billion cubic feet, a volume roughly equal to three-fifths of the total net annual growth in 1976. Achieving this growth would require time since it would take several decades for the effects of most investments to be realized. The bulk of the opportunities are for softwoods.

Nearly three-quarters of the treatment opportunities on an area basis involve reforestation or conversion of existing stands. This category includes regen-

eration of nonstocked areas, harvesting mature stands and regenerating the harvested tracts, and converting existing stands to more desired species. A majority of the opportunities, 74 percent, is on farmer and other private ownerships which collectively contain about 58 percent of the commercial timberland (fig. 6.7). Most of the remaining opportunities are on the 14 percent of the commercial timberland in forest industry ownership. All economic opportunities on the National Forests are currently scheduled or planned and are not shown in table 6.30.

As illustrated in table 6.30, there are economic opportunities for management intensification in all regions. The opportunities are concentrated in the southern regions — 53 million acres in the Southeast and 64 million acres in the South Central. Treatment of these acres, which include almost two-fifths of the commercial timberland acreage in the South, would require investment of $10.1 billion dollars and increase timber growth by more than 9.2 billion cubic feet. Net annual growth in the South in 1976 was 10.7 billion cubic feet.

In the Southeast, the opportunities are predominately for reforestation or conversion on farmer and other private ownerships. In the South Central region, there are also large opportunities for reforestation or conversion. In this region, stocking control is important; it is economical on nearly one-third of the acres.

[54] Dutrow, George F., J. Michael Vasievich, and Merle E. Conkin. Economic opportunities for increasing timber supplies in the United States. U.S. Department of Agriculture, Forest Service and Forest Industries Council. (In process.) In this study, over 400 university, industry, and government foresters in 7 timber supply regions and 25 individual States selected what they considered significant economic opportunities to increase timber supplies through intensified forest management. Although management opportunities were chosen on the basis of augmenting timber supplies, forestry experts made their selections with three general constraints in mind: management actions had to be environmentally acceptable, financially sound, and incremental to efforts already scheduled or planned. In preparing the estimates of economic opportunities, these experts (1) prescribed specific treatments for existing conditions on commercial timberlands, (2) assigned probable costs of application, (3) estimated increases in timber yields from each treatment, and (4) outlined existing ranges of stumpage values. Resource analysts in the Forest Service added acreage estimates for each identified forest condition in the 25 major timber producing States. Over 200 investment opportunities were identified. These opportunities varied by site, physiographic region, and managerial action, and were consolidated into the two major types of management opportunities used in this study — reforestation/conversion and stocking control. All cost and response data for conversion, regeneration, timber stand improvement, cleaning operations, and release practices for a number of sites, geographic categories, and species were averaged. All calculations were based on costs, prices, and interest rates measured in constant 1967 dollars — adjusted to exclude changes resulting from inflation or deflation. Future stumpage prices were based on the equilibrium projections shown in tables 6.27 and 6.29.

There are economic opportunities for management intensification in all regions, but they are concentrated in the South.

In the northern regions (Northeast and North Central) there are 35 million acres — 23 percent of the commercial timberland area — that would yield 4 percent or more on investments in management practices. These opportunities would require an investment of about $2.5 billion and increase timber supplies by 1.5 billion cubic feet a year. Such an increase is about a quarter of the net annual growth in 1976.

In the Northeast region, stocking control is the largest economic opportunity on an area basis. In the North Central region, there are substantial opportunities for investments both in reforestation/stand conversion and stocking control practices. As in the South, the opportunities in the northern regions are predominately on the farmer and other private ownerships.

Nearly all of the remaining economic opportunities for management intensification are on the commercial timberlands on the Pacific Coast. There are about 8.8 million acres in the Pacific Northwest and 7.6 million in the Pacific Southwest which would yield more than 4 percent in constant dollars on investments in various management practices. These investments, about $2.6 billion in total, would increase net annual timber growth by nearly 2 billion cubic feet — about three-fifths of current growth.

Table 6.30—*Economic opportunities[1] for increasing timber supplies in the contiguous United States, by region, treatment opportunity, and ownership[2]*

(Millions)

Region and treatment opportunity	Ownership											
	All ownerships			Other public[3]			Forest Industry			Farmer and other private		
	Total	Total cost of treatment	Net annual growth increment	Total	Total cost of treatment	Net annual growth increment	Total	Total cost of treatment	Net annual growth increment	Total	Total cost of treatment	Net annual growth increment
	Acres	*Dollars*	*Cubic feet*	*Acres*	*Dollars*	*Cubic feet*	*Acres*	*Dollars*	*Cubic feet*	*Acres*	*Dollars*	*Cubic feet*
Northeast												
Reforestation/ type conversion	0.2	10.9	8.5	[5]	0.5	0.4	—	—	—	0.2	10.4	6.1
Stocking control[4]	16.1	714.4	406.4	1.0	31.4	24.2	3.0	233.3	116.9	12.1	449.6	265.4
Total	16.3	725.3	414.9	1.0	31.9	24.6	3.0	233.3	116.9	12.3	460.0	273.5
North Central												
Reforestation/ type conversion	14.3	1,662.0	895.6	1.6	220.1	133.1	0.7	87.0	58.2	12.1	1,354.0	704.3
Stocking control[4]	4.2	81.7	231.7	0.5	10.0	37.4	0.3	2.6	12.4	3.4	69.2	181.9
Total	18.5	1,743.7	1,127.3	2.1	230.1	170.5	1.0	89.6	70.6	15.5	1,424.0	886.2
Southeast												
Reforestation/ type conversion	52.6	4,902.4	4,463.2	2.4	228.8	206.1	7.4	643.6	592.3	42.8	4,030.0	3,664.8
Stocking control[4]	0.6	15.3	23.7	[5]	0.7	0.9	0.3	8.6	13.0	0.2	6.0	9.7
Total	53.2	4,917.7	4,486.9	2.4	229.5	207.0	7.7	652.2	605.3	43.0	4,036.0	3,674.5
South Central												
Reforestation/ type conversion	44.1	4,591.6	4,180.0	1.1	118.8	108.7	9.8	998.9	866.3	33.2	3,473.9	3,204.9
Stocking control[4]	19.5	541.8	425.9	0.4	11.3	9.0	6.3	168.7	133.7	12.8	361.7	283.2
Total	63.6	5,133.4	4,605.9	1.5	130.1	117.7	16.1	1,167.6	1,000.0	46.0	3,835.6	3,488.1

Table 6.30—*Economic opportunities[1] for increasing timber supplies in the contiguous United States, by region, treatment opportunity, and ownership[2] — continued*

(Millions)

Region and treatment opportunity	Ownership											
	All ownerships			Other public[3]			Forest Industry			Farmer and other private		
	Total	Total cost of treatment	Net annual growth increment	Total	Total cost of treatment	Net annual growth increment	Total	Total cost of treatment	Net annual growth increment	Total	Total cost of treatment	Net annual growth increment
	Acres	*Dollars*	*Cubic feet*	*Acres*	*Dollars*	*Cubic feet*	*Acres*	*Dollars*	*Cubic feet*	*Acres*	*Dollars*	*Cubic feet*
Rocky Mountain[6]												
Reforestation/ type conversion	0.1	22.3	5.0	[5]	2.5	0.5	[5]	4.4	0.9	0.1	15.3	3.6
Stocking control[4]	0.1	3.5	3.2	[5]	1.0	0.8	[5]	0.5	0.5	0.1	1.9	1.9
Total	0.2	25.8	8.2	[5]	3.5	1.3	[5]	4.9	1.4	0.2	17.2	5.5
Pacific Northwest												
Reforestation/ type conversion	6.0	1,613.0	1,354.6	1.9	523.9	399.3	2.5	664.1	590.5	1.6	425.1	365.8
Stocking control[4]	2.8	220.1	126.7	0.7	51.9	30.1	1.6	134.1	74.9	0.5	34.0	20.8
Total	8.8	1,833.1	1,481.3	2.6	575.8	429.4	4.1	798.2	665.4	2.1	459.1	386.6
Pacific Southwest												
Reforestation/ type conversion	4.2	691.5	667.1	0.3	49.9	36.6	1.5	232.5	293.8	2.4	409.1	336.7
Stocking control[4]	3.4	92.6	93.4	0.1	5.2	1.7	0.9	31.2	29.4	2.5	56.3	62.3
Total	7.6	784.1	760.5	0.4	55.1	38.3	2.4	263.7	323.2	4.9	465.4	399.0
Contiguous States												
Reforestation/ type conversion	121.5	13,493.7	11,574.0	7.3	1,144.5	884.7	21.9	2,630.5	2,402.0	92.4	9,718.6	8,288.2
Stocking control[4]	46.7	1,669.4	1,311.0	2.7	111.5	104.1	12.4	579.0	308.8	31.6	978.7	825.2
Total	168.2	15,163.1	12,885.0	10.0	1,256.0	988.8	34.3	3,209.5	2,782.8	124.0	10,697.3	9,113.4

[1] Includes those opportunities which would yield 4 percent or more in constant dollars (net of inflation or deflation) on the investment.

[2] All ownerships except National Forests. All economic opportunities for management intensification on National Forests are either presently scheduled or planned and thus do not meet the criteria for inclusion.

[3] All public ownerships except National Forests.

[4] Includes commercial and noncommercial thinning.

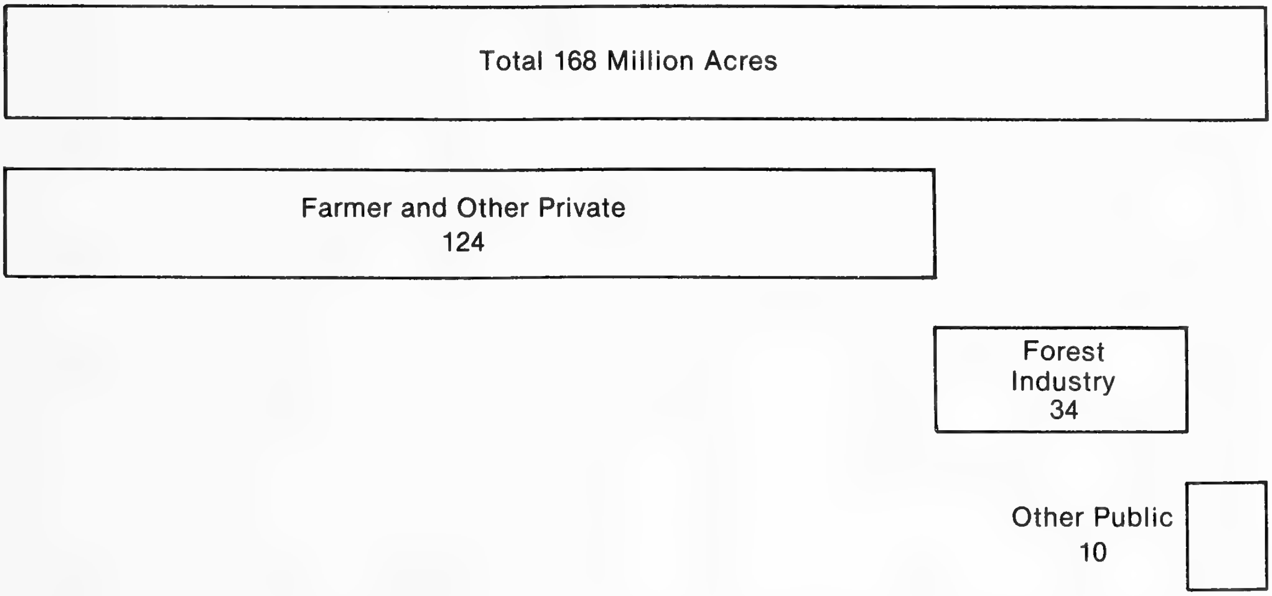
[5] Less than 50,000.

[6] Includes only the economic opportunities in Idaho and Montana. Ongoing studies of the Forest Industries Council suggest that there may be economic opportunities for increasing timber supplies on an additional 900 thousand acres in other Rocky Mountain States.

Note: Columns may not add to totals because of rounding.

Figure 6.7

Ownership Distribution of Economic Opportunities for Management Intensification



In both Pacific Coast regions, reforestation/stand conversion is the largest opportunity in terms of acres, although there are substantial stocking control opportunities.

The above estimates have some obvious limitations. The estimates are largely based on the judgments of experts drawn from the universities, forest industries, the Forest Service, and State forestry agencies. Thus, the estimates may not be an exact measure of the economic opportunities that exist in the various regions of the country. Nonetheless, and after allowances for possible uncertainties, very large opportunities do exist to invest in timber management practices that will yield good rates of return and result in major increases in the Nation's timber supplies.

Prospective Impacts of Implementing the Economic Opportunities for Management Intensification

As discussed above, implementation of the economic opportunities for management intensification would have, in time, large impacts on softwood timber supplies and prices. In recognition of this, the regionally disaggregated economic simulation model described above[55] was used to estimate future softwood supply and price trends, assuming the economic opportunities which would yield 4 percent or more measured in 1967 dollars were implemented on private lands.

Because of the changes in projected supplies and prices resulting from management intensification, it was necessary to reiterate the analysis several times to arrive at an equilibrium solution in which the economic opportunities for management intensification were consistent with the projected changes in prices.

The increases in softwood timber supplies that could be achieved by implementing the economic opportunities are large enough to meet prospective increases in demand while at the same time providing enough timber for large reductions in imports or increases in exports.

The analysis showed that if management were intensified to take advantage of all the opportunities which would yield 4 percent or more (measured in

[55] Adams and Haynes, *op. cit.*

1967 dollars), softwood timber supplies would rise to 12.3 billion cubic feet in 2000, some 11 percent above the base level projection of 11.1 billion cubic feet shown in table 6.22. By 2030, with more time for intensified management activities to affect the timber resource, projected supplies would be 16.1 billion cubic feet, 31 percent above the base level projection of 12.3 billion cubic feet. In line with the location of the economic opportunities shown in table 6.30, the largest part of the increase in supplies resulting from management intensification is in the Southeast and South Central regions.

During the early part of the projection period, softwood stumpage prices with intensified management would rise substantially, although the rates of increase are below those shown in table 6.27. Later in the projection period, as timber supplies increase relative to the equilibrium projections, stumpage prices peak and then begin to decline. The peaks occur in about two decades in the South and four decades in the West. Softwood stumpage prices in 2030 in all regions are significantly below the levels attained in the preceding decades. In the southern regions, for example, where the supply responses from intensified management are concentrated, the index of softwood stumpage prices in 2030 would be close to the trend levels in 1976.

The lower softwood stumpage prices would be reflected in product prices. For example, the average annual rate of increase in softwood lumber prices over the projection period would be about 1.2 percent, considerably below the 1.7 percent per year that is projected without intensified management.

The above estimates of the effects of intensified management have the same limitations as the basic analysis of the economic opportunities for management intensification and the base level and equilibrium level projections of timber supplies. They do show, however, that the potential exists to greatly reduce the adverse social, economic, and environmental impacts of rising relative prices described above.

The Importance of Forest Ownership

While there are many biological and eonomic opportunities to increase timber growth, the owners of commercial timberland determine the purposes for which the land will be used and the way in which it will be managed. There is a broad range of objectives and financial and technical capabilities among the millions of owners of commercial timberland. In addition, there are various legal and institutional constraints and incentives that affect the way in which different owners manage and use their land and timber resources. Together, these considerations determine the extent to which the opportunities to increase timber growth have been and will be realized.

There are some common characteristics among the major commercial timberland ownerships. The National Forests and other public ownerships must rely on appropriations from Congress and other legislative bodies and are managed for a variety of purposes, some of which constrain timber production. Forest industry ownerships, on the other hand, are used primarily to supply timber for wood-using plants; and investments in timber management activities are strongly influenced by economic criteria. Most of the farmer and other private ownerships fall somewhere in between, although they cover the full range from timber production only, to exclusive use for recreation or other nontimber purposes.

Of the constraints facing farmers and other private owners of commercial timberland, perhaps the most important relate to capital and investment incentives. The available information indicates that many of the farmer and other private owners lack the capital for making the investments necessary for most management practices. Further, such investments are not attractive to many owners who do have the capital because of their short planning horizons, lack of knowledge about the opportunities, or the existence of other investment options which they perceive to be better than those in timber management.

Farmers and other private forest owners have many different objectives — they range from timber production only to exclusive use for recreation or other purposes not compatible with timber production. But these ownerships are the key to meeting future timber demands.

Two other factors affect the management of the farmer and other private ownerships for timber production. One is the risk and uncertainty due to the inherent susceptibility of timber to fire, disease, and insects, and the long periods for which timber must be held until it is merchantable. The other is the widespread lack of knowledge by farmer and other private owners regarding timber management practices.

These problems have long been recognized as a major impediment to increasing timber supplies on the farmer and other private ownerships. But what has not been adequately recognized is that many of the benefits of the investments in increasing timber supplies accrue to the society in general in the form of lower prices for stumpage and timber products. Lower prices reduce the cost to consumers of goods such as houses and furniture; the environmental pollution associated with use of substitute materials, such as steel and plastics; dependence on foreign sources of supply; and the rate of use of nonrenewable resources.

These broad economic, social, and environmental benefits, and the likelihood that even direct benefits, such as income from timber sales, will not accrue to current owners because of short tenure or life expectancy, suggest two things. First, there is a strong justification for publicly supported cost sharing and technical assistance programs. Second, existing economic opportunities for management intensification on the farmer and other private ownerships are not likely to be realized in any substantive way without such programs.

There are also important constraints on public ownerships. In recent decades, the commercial timberlands in these ownerships have been increasingly managed for multiple purposes; i.e., for wildlife, outdoor recreation, watershed protection, and forage production, along with timber. More recently, widespread public concern about the natural environment has led to management practices that, while protecting the environment, reduce timber production and increase production costs.

In the future, there undoubtedly will be increasing emphasis on multiple-use management and protection of the environment on the public lands, and to a lesser but significant degree on private lands, particularly those in large ownerships. Various modifications of forestry practices may be necessary, especially on public lands, to insure that intensification of timber management does not seriously impair the environment or damage nontimber uses. Such modifications will be a recognition of the environmental and multiple-use impacts of timber management.

Environmental and Multiple-Use Impacts of Intensified Management

Timber growing and harvesting practices (such as thinning, timber stand improvement, reforestation, prescribed burning, and fertilization and associated timber cutting, road construction, slash burning, or other disturbances) do have important impacts on other uses and the forest environment. It is difficult to generalize about the net impacts. Conditions often vary widely, knowledge of specific impacts is generally lacking, and changes may be offsetting.

Clearly, however, management practices and especially timber harvesting change the vegetative cover. The change can vary depending on the amount of vegetation removed, the length of time required to establish the succeeding vegetation, and the kind of vegetation established.

Soils are affected by vegetation removal, and the associated physical disturbances can cause soil erosion, mass soil movement, and soil compaction. Practices such as slash burning and the removal of branches and leaves can significantly reduce nutrients and damage micro-organisms.

Habitats for some kinds of wildlife are improved with thinnings and other measures that open the forest canopy and increase supplies of food plants. Conversion of brush fields, or stands of inferior quality, by site preparation and planting may damage habitat for some species, particularly in plantations where complete forest canopies develop. Fish can be adversely affected by practices that increase water temperatures and sedimentation and reduce dissolved oxygen.

Access for hunting and fishing and some other recreation travel is usually improved with road construction for logging and other forestry operations. However, adverse recreational impacts also are common as in cases where esthetic qualities of forest areas for recreational viewing, hiking, or camping are reduced by various management practices, especially clearcutting. In addition, man-caused fires are likely to increase with greater access to the forest. Such fires, along with controlled burning, can significantly add to air pollution.

Management practices such as cutting and thinning which create openings in the forest will result in increases in the amount of forage for domestic livestock and grazing wildlife species. As the forest regenerates and seedlings grow into saplings and then into trees, the amount of forage gradually declines. As a result, in closed forests, which are characteristic of much of the commercial timberland area, forage is largely limited to borders and openings. Practices that favor open stands will result in forage production throughout the life of the stand.

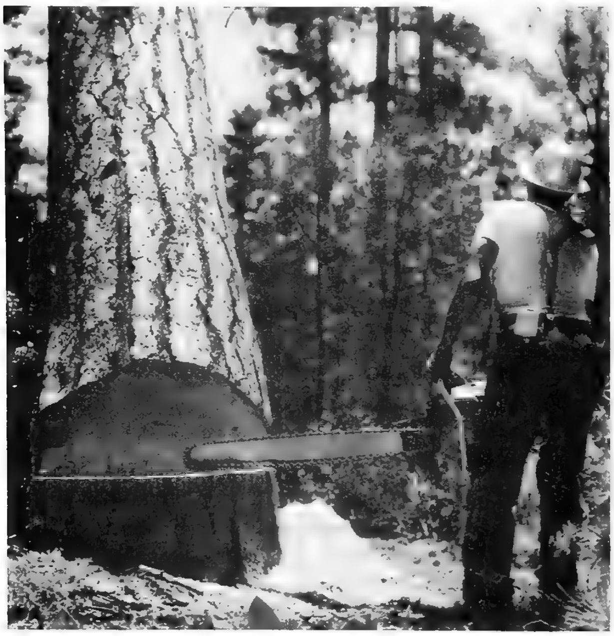
Most management practices affect the esthetics or the beauty of forested areas. Many practices, especially clearcutting and road building, produce effects which are generally considered to be undesirable. However, beauty is subjective — to some persons clearcuts create desirable variety in unbroken forests and provide openings for successional flowering plants which may be of special appeal. Openings also create desirable habitat for many species of wildlife and thus contribute to the pleasures of birdwatchers and hunters. Roads provide access for outdoor recreationists. Associated openings are frequently sought for parking space and campsites.

For many people, the most important effect of timber management activities is on wood supplies. About 5 percent of all employment, much of it in rural areas where other employment opportunities are limited, originates in timber-based economic activity. In one form or another — as housing, furniture, containers, writing paper, newspapers and books, and hundreds of other items — products made from trees affect the quality of life for everyone, including those persons who may never have an opportunity to enjoy the natural beauty of a forest or participate in the various forms of forest-based outdoor recreation.

From the above discussion, it is clear that timber management activities have important effects on the forest environment, the use of forest land for various purposes, and the quality of life. Also, it is clear that the protection of the environment and the use of forest land for purposes such as grazing, outdoor recreation, and wildlife and fish habitat, will have important effects on timber management activities and timber production. Such use may limit harvesting and many treatment practices to relatively small areas and require cleanup of thinning and logging slash. Protection of streams for fish and water values may require that cutting be restricted along streams. Leaving uncut areas for animal escape and cover may be necessary to maintain desired animal populations. Programs for salvage of dead and dying trees may have to be modified in some areas, and patches of timber left to protect food supplies and nesting sites for certain animals and birds.

In making the projections of timber supplies and demand discussed above, the potential impacts of the protection of the environment and multiple-use have been taken into account insofar as possible. It is too early to discern, in any definitive way, the changes that will take place over the next five decades and overall impacts on such things as timber growth and mortality. About all that can be done at this time, and particularly with regard to private lands, is to recognize what is taking place, and to allow for it on a judgmental basis in making projections.

In one form or another, timber from the Nation's forests affects the quality of life for everyone.



Extending Timber Supplies Through Improved Utilization and Research

In addition to the opportunities for increasing timber supplies through management intensification, there are opportunities for extending supplies through improved utilization. These opportunities include increased use of certain kinds of residues, additions to timber harvest, increasing product yields through more efficient processing techniques, and extending use through more efficient construction and manufacturing practices.

There have been significant advances in technology for logging, wood processing, and the use of wood products in recent decades. The demand and supply projections in this chapter are predicated upon continued improvements in these areas. Nevertheless, the rate of progress could be accelerated — there is a large volume of timber and residues that have usable potential.

In 1976, for example, about 1.4 billion cubic feet of residues from growing stock was left unutilized on logging areas. Perhaps two to four times as much volume was left in residual tops and branches, rough and rotten trees, small stems and other unused mate-

rial on harvest sites. These estimates exclude stumps and roots, which are potentially an economic resource in certain areas.

Unsalvaged mortality from suppression, insects, disease, fire, and other destructive agents totaled an additional 4 billion cubic feet. This included 1 billion cubic feet of unsalvaged mortality on National Forests, most of which occurred in the West.

As a result of accumulated mortality, there was about 14 billion cubic feet of salvable dead timber, largely in western softwoods, in 1977. The majority of this dead timber was on National Forests. As has been indicated, nearly all of the mortality on the National Forests occurred in areas that lack roads and are inaccessible for trucks and tractors. The dead trees are also usually scattered over large acreages.

In addition to salvable dead, the timber inventory includes 23.5 billion cubic feet of rotten trees and 43.3 billion cubic feet of rough trees. The rough and rotten inventory is mainly composed of hardwood trees. These rough and rotten trees are also scattered over large acreages and potential uses are largely limited to those where quality is not an important consideration.

Unused wood residuals at primary manufacturing plants in the United States amounted to about 0.5 billion cubic feet in 1976—4 percent of the wood input (fig. 6.8). The decline was mainly due to a large rise in use of sawmill and veneer mill residuals in pulp and particleboard production. Increased use of wood residuals for fuel and of veneer cores for lumber also contributed to the reduction in waste. The remaining primary plant residues may be close to a practical minimum. There will probably always be some residues at primary manufacturing plants because of the small volumes generated or location relative to consuming plants.

Urban wood wastes constitute a substantial solid-waste disposal problem and a potential source of increased product supply. The major categories of such wastes are waste paper; solid wood product residues from building construction, building demolition, and used pallets, crates, and dunnage; and urban tree removals. A recent estimate of annual formation of such wastes is as follows:

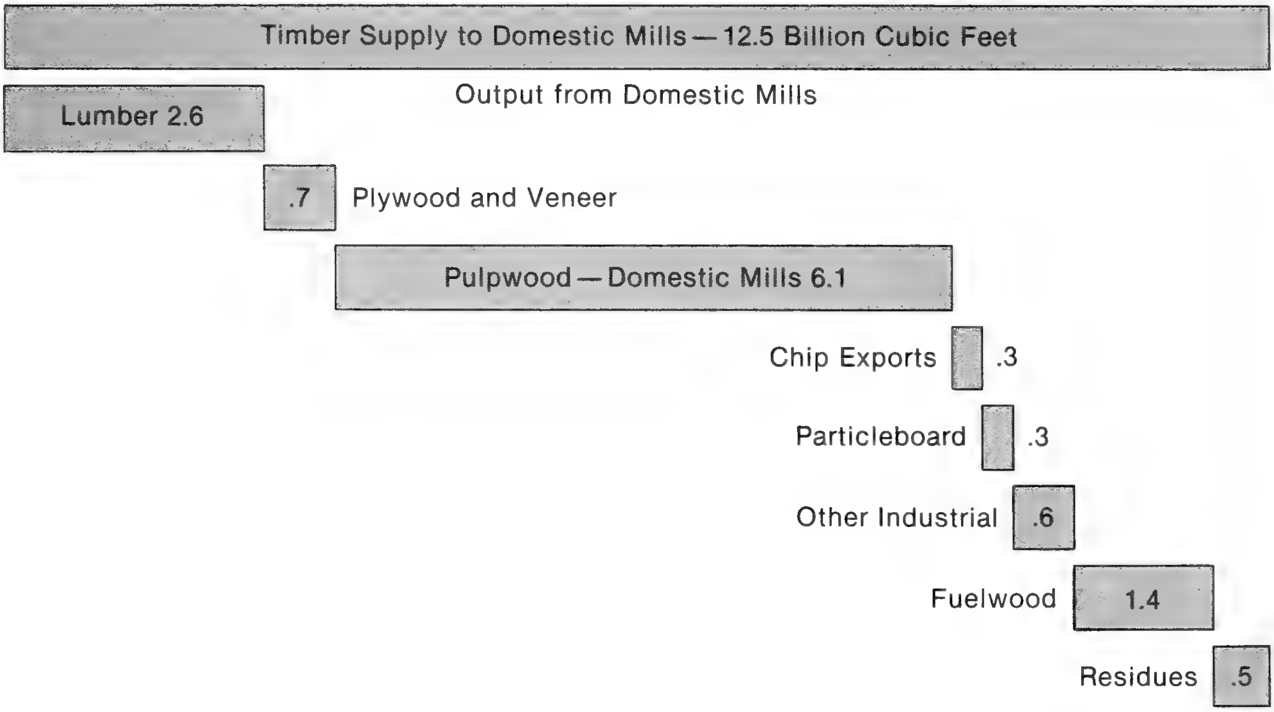
Waste paper	45 million tons
Waste solid wood products	14 million tons
Urban tree removals	3 million tons

Recycling and fuel uses consume from 20 to 30 percent of the urban waste paper annually. Salvage for products or fuel probably accounts for about one-

There are still large volumes of wood left after harvest in some areas, and particularly in the old growth forests of the West. Most of this material is low quality and suitable only for the production of fiber products or use as fuel.

Figure 6.8

Timber Supply to and Output from Domestic Mills, 1976



fourth of the solid wood waste and one-seventh of the urban tree removals. The remainder of this material is disposed of in landfills, dumps, or incinerators.

Possibilities for Improvement

Some improvement in utilization of dead or defective timber on National Forests has been made possible by establishment of a fund, pursuant to the National Forest Management Act of 1976, which can be used to pay Forest Service costs of preparing and administering salvage timber sales. However, in most cases, current market prices for such materials are lower than the costs of harvest and transport to mills. Thus, a major need is for techniques and equipment that will reduce these costs. Important progress is now underway on mechanized systems that allow rapid collection — and in some cases, onsite chipping for fuel or pulpwood — of whole stems or trees. Improvements are also being made in ue of aerial systems of logging to reduce road construction needs and to permit harvesting of timber on areas where environmental impacts would otherwise be unacceptable.

Another opportunity to reduce waste in timber harvest is through quality control in felling and bucking. Studies both in the United States and Canada have shown that such control could add several percent to sawlog and veneer log output.

Improved lumber and plywood processing technology can extend timber supplies substantially. Particularly important is the need for cost-effective systems of manufacturing lumber and plywood from small-diameter logs and short logs. Promising approaches include high-speed electronic scanning and automated control systems, gluing techniques to produce wide-width or long-length products equivalent to lumber sawn from large logs, and automated grading systems. Another developing possibility is techniques for producing and marketing construction lumber from hardwoods such as yellow-poplar and aspen.

Quality control in sawmilling, lumber drying, and remanufacturing offers immediate opportunities for increased product supply. Studies have shown that many sawmills can improve yield by as much as 10 percent through increased attention to equipment maintenance and machine settings. Careful application of existing technology for drying can greatly reduce lumber degrade and net costs. Techniques for calculating least-cost lumber grades for furniture parts and other manufactured items can reduce costs and the demands for high-grade lumber.

Technology for manufacturing panel products — such as particleboard, medium-density fiberboard, and composite veneer-particle panels — has expanded greatly in recent years. Such technology offers large possibilities for use of residues, low quality trees, and small logs. Both hardwood and softwood species may be used in many panel products. Primary obstacles to increased industrial development are high capital and adhesives costs. Panel products for roof sheathing and subflooring typically must be made with phenolic resins derived from high-cost petrochemicals. Thus, techniques for reducing the amount of phenolic resin required per ton of product or for making lower-cost adhesives would enhance the potential of these resource-efficient materials.

In the pulp and paper industry, there are many opportunities for expanding the resource base and for increasing product yields. Continued development of techniques for harvesting and pulping whole-tree chips could greatly increase per-acre harvest and reduce logging residue problems. Improvements in paper-making techniques would allow increased use of pulp from high-yield processes and from hardwoods. Recycling of waste paper and paperboard is much more prevalent in Japan and some European nations than in the United States. Chief impediments to recycling are problems with contaminants, such as glue, and losses in strength during reprocessing.

Reduction of fuels and power costs in forest industries would lower per-unit manufacturing costs and thus increase economic supply of products. Possibilities include development of energy-efficient processing methods and expanded use of wood and bark fuels. Many mills have turned to fuels from manufacturing residuals, and a few are harvesting low-grade roundwood specifically for energy. Improvement in techniques for harvesting, processing, and storing fuelwood could help expand such use. Another possibility, now applied in a few areas, is distribution of surplus stream and electricity from forest products mills through local utilities. This arrangement can reduce the net cost of energy to the mills.

Improved engineering and construction practices could conserve wood materials in houses and other structures. It has been estimated that such improvements could save 10 to 20 percent of the dimension lumber required in a conventional house without loss in performance. Proper use of preservative-treated products, insecticides to control termites, and careful application of water-repellants could greatly extend the useful life of most wood products and reduce demand on timber resources. Major deterrents to the conservation of wood in building construction and maintenance are: the inadequacy of engineering performance criteria for products and structures, the fragmented nature of the building industry, and institutional problems involving the many national, State, and local authorities that govern building codes.

Reduction of Demand for Timber Products

Beyond the opportunities to increase and extend timber supplies, there is another set of opportunities — those which will reduce demand for timber products. Although there are numerous opportunities to reduce demand, nearly all the possibilities, short of rationing or other authoritarian controls, seem to involve the use of substitute materials or increases in imports. Such shifts would have the same undesirable economic, social, and environmental effects as those resulting from rising relative prices described above. However, there does seem to be one way or opportunity to reduce demand which would have no adverse impacts — the proper maintenance and renovation of existing structures. This possibility, if practiced on a more extensive scale, could significantly lower demands for timber, and other materials as well, below the volumes needed for new replacement structures.

The General Role of Research

The above discussion has been concerned in part with the role of research in increasing and extending timber supplies. Through research, it may also be possible to develop ways of integrating and balancing multiple-uses of forest land and reducing the conflicts which are likely to result from the rapidly expanding demands for timber, wildlife, grazing, outdoor recreation, water, and other forest-related goods and services.

Finally, research has a general role in developing the facts of analyses necessary for the formulation and guidance of timber policies and programs — the basic purpose of this Assessment. First, there is a need to intensify the collection of basic data on the timber resource so that it is current and statistically reliable for relatively small resource planning areas such as a county or river basin. Second is the need to expand the collection of data to include information on the physical responses of forest land and timber stands to various management practices and the interactions on other resources such as water and wildlife. Third, there is a need to further explore the economic, social, and environmental implications of the growing scarcity of timber. This is a basic need — it is the societal basis for changing policies and programs. The results of this research are thus likely to have major impacts on the future course of forestry in the country.

Chapter 7. — Water

This chapter presents information on: (1) Recent trends in water use, both for consumptive and nonconsumptive uses, with projections to 2030; (2) the current and prospective water supply situation; (3) comparisons of projected consumptive water demands with supplies, and identification of the location and significance of likely quantity imbalances; (4) identification of major water quality problems; and (5) opportunities for dealing with quantity and quality problems through forest and range land management.

Responsibility for national water assessments was assigned to the U.S. Water Resources Council by the Water Resources Planning Act of 1965. Much of the information in this section has been condensed from the Council's recently completed study "The 1975 Assessment of Water and Related Land Resources."[1] For the assessment of water quality, the primary source was "The National Water Quality Inventory Report for 1976."[2] In addition, the Forest Service has made a specific attempt to assess water quality from forest and range land.

A number of other studies contain information on the Nation's water resources which supplement the above work, including:

National Water Commission. Water policies for the future, final report to the President and to Congress. U.S. Gov. Printing Office, Washington, D.C. 579 p. 1973.

U.S. Water Resources Council. Water regions and subregions for the national assessment of water and related land resources. Water Resources Council, Washington, D.C. 75 p. 1970.

United States Environmental Protection Agency. National water quality inventory, 1976 Report to Congress. U.S. Gov. Printing Office, Washington, D.C. 1976.

Anderson, H. W., M. D. Hoover, and K. G. Reinhart. Forest and water: Effects of forest management on floods, sedimentation, and water supply. U.S. Department of Agriculture, Forest Service, General Tech. Rep. PSW-18. Pacific Southwest For. and Range Exp. Stn., Berkeley, Calif. 1976.

[1] U.S. Water Resources Council. The 1975 assessment of water and related land resources. (In process.)

[2] U.S. Environmental Protection Agency. National water quality inventory, 1976 Report to Congress. U.S. Gov. Printing Office, Washington, D.C. 1977.

Overall, the United States has an abundant supply of water. In 1975, the Nation consumptively used about 106.6 billion gallons a day, while average supplies via natural runoff averaged about 1,400 billion gallons a day. Unfortunately, these averages do not adequately portray the situation. While an abundance of water occurs in many sections of the country, there are some sections where the need greatly exceeds the supply, the quality of available water is very poor, or both.

In addition, water is subject to multiple uses in the sense that the water in a stream or lake may be used for recreation, support for aquatic life, for residential and commercial purposes, and for irrigation. The same water may be used several times for different purposes as it flows from the headwaters of a major river to the ocean. To a substantial degree, the reuse of water depends on the ability to maintain high-quality water in streams and lakes.

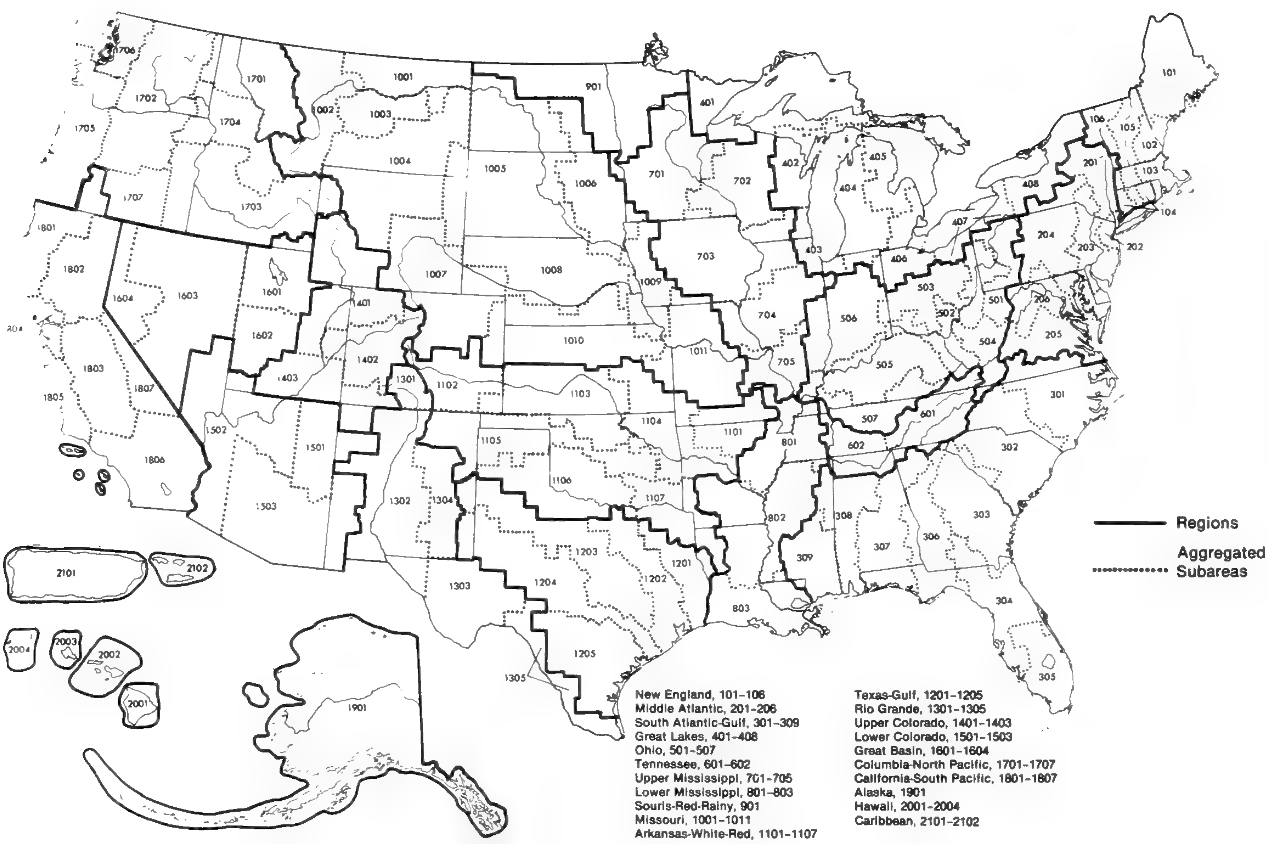
Basically, then, water problems exist because water generally is not a highly transportable commodity. The cost of transporting water outside natural watersheds is usually prohibitive for all but the highest value uses. As a result, an overall nationwide analysis of water supplies and demands can be misleading. Most water problems can be defined only on a regional or even local basis. In recognition of this fact, projections of water demands and supplies are presented for regions that represent geographic areas with common water management situations. The geographic delineation used in this study is shown in figure 7.1. The water resource regions are listed on the map margin as New England, Middle Atlantic,. . . ., Caribbean, and are delineated by solid lines and numbered (01), (02), etc. The second order delineations are subdivisions of the first, and are called subregions. These subregions on figure 7.1, delineated by dotted lines, are groups of counties that closely approximate hydrologic areas which could be (1) a river system or systems, (2) a reach of a river or its tributaries, (3) a closed basin, or (4) a group of rivers forming a coastal drainage area.

The Demand for Water

Estimates of water withdrawal and consumptive uses are presented here by water resource region. Then, to facilitate analysis of problems at a more meaningful geographic level, water supply and consumptive uses (shown as depletion rates) are presented at the subregion level. These subregions are then aggregated into the Resources Planning Act Regions used in this document to facilitate the development of the Forest Service program.

Figure 7.1

Water Resource Regions



Three categories of water use are generally recognized: (1) Withdrawal use which removes water from its natural course, uses it, and then returns it to a stream or underground source where it is available for reuse; (2) consumptive use which represents that portion of the withdrawal consumed through evaporation, transportation, or by discharge to irretrievable locations: and (3) instream uses such as boating, fishing, navigation, and hydroelectric power.

The 1975 National Water Assessment prepared by the Water Resources Council contains estimates of withdrawals, consumptive use, and, to some extent, instream uses for 1975, with projections for 1985 and 2000.[3]

In this report, the projections for water demand beyond 2000 have been made by the Forest Service by extending the general trends shown in the projections by the Water Resources Council. The estimates for 1980 and 1990 are interpolated from the projections of the Council.

Water Withdrawals by Major Use

Freshwater withdrawals were approximately 339 billion gallons a day in 1975 (table 7.1). Irrigation was the largest withdrawal use, accounting for 47 percent of the total (fig. 7.2). Withdrawals for steam electric cooling were second in importance (26 percent). Another 15 percent was used in manufacturing. Domestic use and mineral extraction activities accounted for most of the remainder.

Demand for water withdrawals is projected to decrease to about 306 billion gallons per day by the year 2000. Most of the projected decrease should occur before 2000 and is concentrated in manufacturing, steam electric cooling, and irrigation. These declines are expected because of increased emphasis on water conservation and the adoption of tech-

[3]U.S. Water Resources Council. The 1975 assessment of water and related land resources, *op. cit.*

Table 7.1 —*Fresh water withdrawals in the United States in 1975, by major use, with projections of demand to 2030*

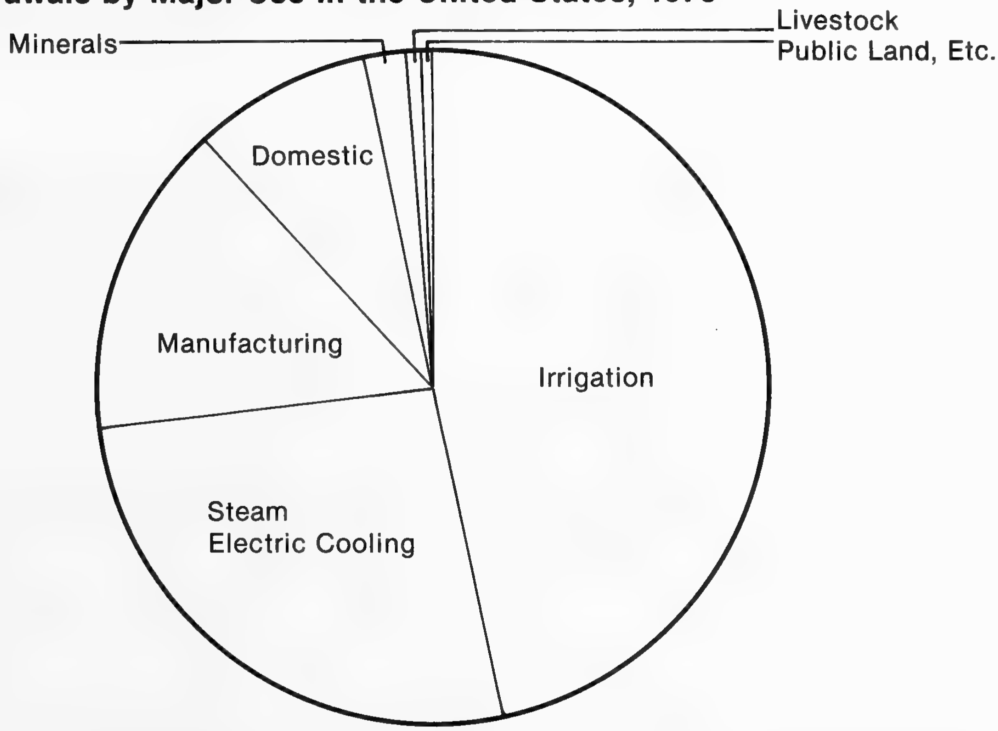
(Million gallons a day)

Major use	1975	1985	1990	2000	2010	2020	2030
Irrigation	158,743	166,252	160,710	153,846	155,121	151,515	148,518
Steam electric	88,916	94,858	87,602	79,492	78,544	74,508	70,472
Manufacturing	51,222	23,687	22,345	19,669	19,009	22,771	26,392
Domestic and commercial:							
Central (municipal)	21,164	23,983	25,259	27,918	30,643	32,948	36,032
Noncentral	2,092	2,320	2,317	2,400	2,591	2,727	2,868
Commercial	5,530	6,048	6,263	6,732	7,219	7,701	8,181
Minerals	7,055	8,832	9,638	11,328	13,048	14,923	16,465
Livestock	1,912	2,233	2,241	2,551	2,767	3,000	3,211
Public lands and other	1,866	2,162	2,240	2,461	2,732	2,960	3,200
Total	338,500	330,375	318,615	306,397	311,674	313,053	315,339

Source: data for 1975, 1985 and 2000 from U.S. Water Resources Council. *The Nation's Water Resources 1975-2000.* Data for all other years are Forest Service estimates derived by interpolating or extending the trends shown by the projections of the Water Resources Council.

Figure 7.2

Water Withdrawals by Major Use in the United States, 1975



nology that will permit more water recycling to meet environmental standards. Projected manufacturing withdrawals show the greatest rate of decline in the 1975-2000 period, falling 61 percent from 51 billion gallons per day to 19.7 billion gallons per day; after 2000 some increase is expected.

Contrary to the overall declining trend, withdrawals for domestic and commercial uses and mineral extraction are expected to increase moderately.

Water Withdrawals by Region and Use

Total water withdrawals by water resource region are shown in table 7.2. Current and projected withdrawals for each region reflect both the relative availability of water and the uses that are most common in the region. For example, irrigation is the major withdrawal use nationwide, but it is of little importance in humid regions where precipitation is distributed throughout the year, such as in the New England and Ohio regions. Similarly, withdrawals for steam electric cooling are relatively low in the Columbia-North Pacific region, which is heavily dependent on hydroelectric power at the present time.

Total withdrawals are now greatest in the Great Lakes, Ohio, Missouri, Columbia-North Pacific, and California-South regions. For the first two regions, totals reflect the importance of fossil-fueled steam generating systems and a concentration of manufacturing activities (tables 7.4 and 7.5); for the other three regions, withdrawals for irrigation are by far the most important (table 7.3). The latter three regions together account for more than 60 percent of all irrigation withdrawals in the United States.

Withdrawals for irrigation are expected to continue to increase over the next 10 years, but eventually will decline because of the adoption of water-conserving techniques such as drip irrigation and channel lining. For the Missouri, California, and Pacific Northwest regions, the proportion of total withdrawals is expected to increase from 60 percent to 66 percent, but the overall regional pattern of water use for irrigation is not likely to change drastically.

Steam electric generation currently accounts for about 22 percent of total water withdrawals (fig. 7.2). This rate will probably decrease to about 19 percent or 80 billion gallons a day by 2000. The largest withdrawals for power cooling in 1975 were in the South Atlantic Gulf, Great Lakes, and Ohio regions, which accounted for about 65 percent of the withdrawals for that purpose (table 7.4).

Because of the expected adoption of new cooling technology, several regions including the Great Lakes and Ohio will experience significant declines in withdrawal use in future years. Significant withdrawal increases are expected in the Lower Mississippi and Texas Gulf regions.

Water withdrawals for manufacturing will decline from 51 to 20 billion gallons a day from 1975 to 2000, largely because of increased use of recycling in response to water pollution regulations (table 7.4). The Great Lakes and Ohio regions were the largest users of manufacturing water in 1975 (47 percent), but their part in manufacturing withdrawals is expected to decline to about 24 percent of the total in 2000, with the South Atlantic Gulf and Texas Gulf becoming more significant (table 7.5).

Domestic and commercial use was the next largest withdrawal user, accounting for 8 percent of all withdrawals in 1975 (tables 7.6 through 7.8). This use is expected to increase to about 12 percent of the total by 2000, surpassing manufacturing as the third largest withdrawal user. The regional distribution of residential and commercial users is related closely to population density, which is not expected to change much in the next 25 years.

The remaining uses, including minerals production and public land administration, account for less than 3 percent of total withdrawal use. Although they are not the major users in any water resource region, their current and potential importance in many local areas may be great, especially where water supplies are limited.

Consumptive Use of Water

Much of the water withdrawn for most uses is returned to a water source for reuse. For example, of 51 billion gallons a day withdrawn for manufacturing in 1975, about 45 million gallons a day were returned for reuse. On the other hand, irrigation consumes, through transpiration and evaporation, over one-half (54 percent in 1975) of the total water withdrawn for that purpose. Consumptive use of water is generally considered more critical than water withdrawal because it represents an absolute reduction in available water supply. Once used consumptively, water is not available for reuse until it completes its passage through the phases of the hydrologic cycle to return to earth in some form of precipitation.

The greatest consumptive use of water in the United States in 1975 was for irrigation which accounted for 81 percent of the total (table 7.9 and fig. 7.3). Manufacturing and domestic central supplies accounted for another 10 percent, with the remaining 9 percent about equally divided among the other uses. Trends in consumptive use are considerably different from those for withdrawals. Without exception, all consumptive uses are expected to increase in

Table 7.2 — *Fresh water withdrawals and consumption in the United States in 1975, by water resource region, with projections of demand to 2030*

(Million gallons a day)

Water resource region	Withdrawals							Consumption						
	1975	1985	1990	2000	2010	2020	2030	1975	1985	1990	2000	2010	2020	2030
New England	5,098	3,939	3,825	3,230	3,356	3,662	3,962	481	647	777	1,063	1,268	1,453	1,705
Middle Atlantic	18,300	15,857	15,197	13,873	14,273	15,028	15,782	1,843	2,472	2,942	3,548	4,196	4,862	5,532
South Atlantic Gulf	24,510	25,457	26,040	28,340	28,699	29,329	29,580	4,867	6,772	8,236	10,053	11,588	13,138	14,690
Great Lakes	42,813	32,666	30,196	25,623	25,807	26,143	26,483	2,598	3,300	4,175	4,693	5,728	7,310	7,788
Ohio	34,934	27,838	25,511	16,925	17,062	16,970	17,661	1,798	2,527	3,244	4,332	5,375	6,196	7,561
Tennessee	7,412	7,131	6,541	6,013	5,947	5,971	5,946	313	647	738	1,105	1,377	3,801	1,947
Upper Mississippi	12,401	10,386	9,806	7,910	8,100	8,367	8,511	1,145	1,604	1,904	2,688	3,228	3,809	4,383
Lower Mississippi	14,567	17,453	18,984	24,841	24,827	24,479	24,121	4,027	4,554	4,793	5,511	6,027	6,621	7,163
Souris-Red Rainy	336	329	338	587	648	636	645	112	204	209	446	478	489	518
Missouri	38,016	48,037	45,781	44,359	45,037	44,538	44,034	15,469	19,206	19,117	19,913	20,949	21,802	22,450
Arkansas-White-Red	12,868	13,799	13,322	13,337	13,467	13,363	13,656	8,064	8,769	8,882	8,887	9,476	9,965	10,518
Texas Gulf	16,925	15,932	15,559	14,991	15,923	16,558	16,893	11,259	10,227	10,643	10,529	11,696	12,805	13,971
Rio Grande	6,321	6,204	5,989	5,633	5,714	5,719	5,731	4,240	4,320	4,290	4,016	4,200	4,344	4,487
Upper Colorado	6,869	7,841	7,532	7,519	7,599	7,568	7,527	2,440	3,018	3,024	3,232	3,423	3,554	3,748
Lower Colorado	8,917	8,528	8,123	7,857	7,984	8,029	8,078	4,595	4,754	4,755	4,708	4,995	5,244	5,393
Great Basin	7,991	7,316	7,090	7,258	7,399	7,463	7,524	3,779	3,765	3,782	4,036	4,265	4,458	4,652
Pacific Northwest	37,495	38,098	36,600	33,852	33,960	33,972	33,832	11,913	14,610	14,484	15,196	16,061	16,834	17,518
California	39,636	40,549	39,216	41,265	42,700	41,822	41,824	26,641	27,932	27,801	29,699	31,080	32,172	33,265
Alaska	305	433	448	745	847	981	1,053	58	207	236	459	533	630	704
Hawaii	1,879	1,619	1,561	1,349	1,379	1,458	1,451	605	636	662	666	716	801	844
Caribbean	907	963	956	890	946	997	1,045	343	374	371	300	315	332	345

Source: See source note table 7.1.

Table 7.3 — *Fresh water withdrawals and consumption for irrigation in the United States in 1975, by water resource region, with projections of demand to 2030*

(Million gallons a day)

Water resource region	Withdrawals							Consumption						
	1975	1985	1990	2000	2010	2020	2030	1975	1985	1990	2000	2010	2020	2030
New England	35	41	39	46	46	45	37	25	29	29	33	34	35	36
Middle Atlantic	265	366	350	481	481	473	466	196	269	265	354	367	375	384
South Atlantic Gulf	3,464	4,008	3,829	4,509	4,509	4,436	4,363	2,752	3,184	3,132	3,597	3,724	3,812	3,899
Great Lakes	145	211	202	282	282	277	273	114	169	166	232	240	246	251
Ohio	47	68	65	91	91	89	88	37	53	51	74	77	78	80
Tennessee	14	18	17	21	21	21	20	11	14	14	17	18	18	18
Upper Mississippi	192	283	270	387	386	381	374	153	230	226	323	334	342	350
Lower Mississippi	4,580	4,559	4,355	4,444	4,444	4,372	4,300	3,065	3,204	3,152	3,272	3,388	3,467	3,546
Souris-Red Rainy	46	144	138	434	434	427	420	37	116	114	350	373	371	390
Missouri	31,636	39,376	37,613	36,236	36,736	36,142	35,550	14,214	17,597	17,312	17,607	18,232	18,922	19,083
Arkansas-White-Red	9,980	10,483	10,014	9,776	9,776	9,618	9,460	7,048	7,468	7,347	7,125	7,378	7,550	7,722
Texas Gulf	11,538	9,333	8,915	7,427	7,427	7,307	7,187	9,347	7,597	7,474	6,100	6,317	6,464	6,611
Rio Grande	5,684	5,498	5,252	4,873	4,873	4,794	4,716	3,886	3,920	3,717	3,570	3,696	3,783	3,869
Upper Colorado	6,400	7,223	6,900	6,672	6,672	6,564	6,457	2,194	2,657	2,614	2,741	2,838	2,905	2,971
Lower Colorado	7,989	7,299	6,872	6,343	6,343	6,240	6,138	4,026	3,962	3,898	3,720	3,852	3,942	4,032
Great Basin	6,969	6,120	5,846	5,825	5,825	5,731	5,637	3,225	3,082	3,032	3,196	3,309	3,387	3,464
Pacific Northwest	33,181	34,639	34,088	29,961	29,961	29,477	28,994	11,026	13,363	12,981	13,213	13,279	15,001	14,321
California	34,539	34,863	34,302	34,764	34,764	34,356	33,281	24,282	25,134	24,727	26,311	27,245	28,881	28,218
Alaska	4	4	4	4	4	4	4	3	3	3	3	3	3	3
Hawaii	1,447	1,226	1,171	951	951	936	920	474	481	473	473	490	501	513
Caribbean	516	490	468	319	319	314	309	276	289	284	195	201	207	211
Total	158,743	166,252	160,710	153,846	155,121	151,515	148,518	86,391	92,820	91,011	92,506	95,395	100,290	99,972

Source: See source note table 7.1.

Table 7.4 — *Fresh water withdrawals and consumption for steam electric cooling in the United States in 1975, by water resource region, with projections of demand to 2030*

(Million gallons a day)

Water resource region	Withdrawals							Consumption						
	1975	1985	1990	2000	2010	2020	2030	1975	1985	1990	2000	2010	2020	2030
New England	1,263	1,069	959	375	368	349	330	21	18	27	167	221	280	338
Middle Atlantic	7,463	7,130	6,398	4,657	4,567	4,333	4,098	103	224	331	644	853	1,079	1,305
South Atlantic Gulf	12,768	12,912	13,374	13,952	13,683	12,981	11,961	153	722	1,733	1,857	2,462	3,113	3,765
Great Lakes	24,362	22,689	20,358	16,061	15,752	14,943	14,133	175	497	735	1,384	1,834	2,820	2,806
Ohio	21,022	21,008	18,850	10,574	10,370	9,838	9,305	324	656	970	1,692	2,243	2,837	3,430
Tennessee	4,799	5,738	5,149	4,581	4,493	4,262	4,031	42	231	341	417	553	699	845
Upper Mississippi	7,644	6,347	5,695	3,537	3,469	3,291	3,113	129	352	520	1,079	1,430	1,809	2,187
Lower Mississippi	4,175	9,313	11,987	16,656	16,366	15,525	14,684	54	118	174	291	386	488	490
Souris-Red Rainy	102	43	38	31	30	29	27	1	0	0	0	0	0	0
Missouri	3,540	5,834	5,231	4,938	4,843	4,594	4,345	68	239	353	637	844	1,068	1,291
Arkansas-White-Red	498	1,026	921	1,012	993	942	891	89	237	350	457	606	766	927
Texas Gulf	724	1,000	897	1,713	2,218	2,105	1,990	99	270	399	991	1,317	1,667	2,015
Rio Grande	34	16	14	10	10	9	9	18	9	13	5	7	8	10
Upper Colorado	103	157	141	201	197	187	177	39	106	140	151	200	253	306
Lower Colorado	68	150	134	154	151	143	136	63	134	130	126	167	211	255
Great Basin	33	65	58	82	80	76	72	3	42	62	52	69	87	105
Pacific Northwest	260	203	238	580	469	540	510	13	104	153	344	456	576	697
California	42	158	142	367	360	341	323	25	101	149	242	321	405	491
Alaska	36	20	15	11	22	20	19	0	2	3	5	7	8	10
Hawaii	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caribbean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	88,916	94,858	87,602	79,492	78,544	78,508	70,472	1,419	4,062	6,583	10,541	14,376	17,674	21,373

Source: See source note table 7.1.

Table 7.5 — *Fresh water withdrawals and consumption for manufacturing in the United States in 1975, by water resource region, with projections of demand to 2030*

(Million gallons a day)

Water resource region	Withdrawals							Consumption						
	1975	1985	1990	2000	2010	2020	2030	1975	1985	1990	2000	2010	2020	2030
New England	2,170	1,022	942	781	728	870	1,011	192	332	446	567	692	827	961
Middle Atlantic	5,416	2,526	2,330	1,942	1,758	2,100	2,441	607	934	1,260	1,361	1,670	1,995	2,319
South Atlantic Gulf	4,103	3,377	3,353	3,318	3,280	3,917	4,554	611	1,203	1,626	2,532	3,116	3,721	4,326
Great Lakes	13,220	4,106	3,677	2,821	2,662	3,178	3,696	1,474	1,719	2,317	2,059	2,529	3,020	3,511
Ohio	10,881	3,323	2,996	2,341	2,276	2,718	3,160	817	1,095	1,471	1,759	2,162	2,582	3,002
Tennessee	2,093	765	733	671	665	795	925	147	266	358	514	632	755	879
Upper Mississippi	2,030	886	830	728	658	785	914	240	309	415	506	625	746	868
Lower Mississippi	4,163	1,634	1,544	1,365	1,381	1,649	1,912	314	552	743	1,067	1,312	1,567	1,822
Souris-Red Rainy	102	44	39	31	29	36	41	13	19	24	23	28	34	39
Missouri	669	315	305	292	261	313	363	136	122	162	202	248	297	345
Arkansas-White-Red	713	476	476	480	463	554	643	165	232	314	360	440	526	611
Texas Gulf	1,932	2,559	2,521	2,444	2,479	2,961	3,442	571	1,003	1,357	1,917	2,355	2,813	3,270
Rio Grande	19	42	38	32	31	37	43	5	15	20	24	29	35	41
Upper Colorado	4	2	2	2	2	3	3	2	1	1	2	2	3	3
Lower Colorado	89	92	122	138	134	159	185	55	54	73	104	127	151	176
Great Basin	112	93	94	98	98	118	137	24	42	57	77	93	112	130
Pacific Northwest	2,324	1,321	1,257	1,132	1,139	1,361	1,582	329	501	675	880	1,082	1,293	1,503
California	796	830	828	828	734	877	1,019	257	375	499	567	697	833	968
Alaska	134	93	91	86	86	126	120	26	41	55	68	82	120	134
Hawaii	251	181	167	139	145	214	201	74	88	119	112	138	203	210
Caribbean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	51,222	23,687	22,345	19,669	19,009	22,771	26,392	6,059	8,903	11,992	14,699	18,059	21,632	25,117

Source: See source note table 7.1.

Table 7.6 — *Fresh water withdrawals and consumption for domestic central use in the United States in 1975, by water resource region, with projections of demand to 2030*
(Million gallons a day)

Water resource region	Withdrawals							Consumption						
	1975	1985	1990	2000	2010	2020	2030	1975	1985	1990	2000	2010	2020	2030
New England	1,011	1,097	1,155	1,222	1,341	1,459	1,577	96	103	109	114	125	137	148
Middle Atlantic	3,627	4,095	4,311	4,758	5,223	5,682	6,141	505	565	596	650	715	780	846
South Atlantic Gulf	1,931	2,369	2,494	3,005	3,298	3,589	3,879	657	816	861	1,057	1,164	1,269	1,375
Great Lakes	2,946	3,264	3,436	3,717	4,080	4,439	4,798	280	308	325	349	384	419	454
Ohio	1,561	1,751	1,844	2,013	2,210	2,013	1,598	175	196	207	227	250	273	295
Tennessee	210	259	273	323	355	385	417	26	32	34	39	43	47	51
Upper Mississippi	1,280	1,440	1,516	1,653	1,814	1,974	2,133	178	200	211	231	254	277	300
Lower Mississippi	595	657	692	729	800	871	941	255	279	294	307	338	369	399
Souris-Red Rainy	41	44	46	47	51	56	61	17	18	19	19	21	23	25
Missouri	872	959	1,010	1,083	1,189	1,293	1,398	207	227	240	256	282	307	333
Arkansas-White-Red	667	737	776	830	911	991	1,071	236	262	277	293	322	352	381
Texas Gulf	1,152	1,320	1,390	1,565	1,718	1,869	2,020	379	431	455	508	559	610	661
Rio Grande	254	276	290	301	330	359	388	132	144	152	158	174	190	205
Upper Colorado	67	73	77	83	88	96	103	25	27	25	29	30	32	35
Lower Colorado	416	512	539	649	712	775	838	195	240	263	304	335	365	295
Great Basin	333	391	411	468	514	559	604	126	146	154	174	191	209	226
Pacific Northwest	720	776	817	874	959	1,043	1,128	157	168	177	188	207	226	244
California	2,958	3,338	3,515	3,839	4,214	4,584	4,955	1,246	1,403	1,481	1,611	1,774	1,935	2,096
Alaska	80	101	106	132	145	158	170	4	5	5	7	8	8	9
Hawaii	148	172	181	209	229	250	269	44	52	55	63	69	76	99
Caribbean	295	352	370	421	462	503	543	39	46	48	56	61	67	73
Total	21,164	23,983	25,259	27,921	30,643	32,948	36,032	4,976	5,665	5,988	6,638	7,308	7,971	8,550

Source: See source note table 7.1.

Table 7.7—*Fresh water withdrawals and consumption for domestic noncentral use in the United States in 1975, by water resource region, with projections of demand to 2030*

(Million gallons a day)

Water resource region	Withdrawals							Consumption						
	1975	1985	1990	2000	2010	2020	2030	1975	1985	1990	2000	2010	2020	2030
New England	111	126	126	134	145	152	160	68	76	75	82	88	91	94
Middle Atlantic	327	372	371	410	443	466	490	200	225	223	246	264	275	287
South Atlantic Gulf	357	432	463	481	519	547	574	223	263	261	288	311	324	337
Great Lakes	321	350	355	360	389	409	430	196	211	210	214	231	241	251
Ohio	281	317	322	330	356	375	394	174	193	191	197	211	221	230
Tennessee	53	60	60	60	65	68	72	33	37	32	37	41	44	45
Upper Mississippi	170	169	170	155	167	176	185	104	102	102	93	80	83	86
Lower Mississippi	60	64	64	61	66	69	73	39	40	40	37	40	41	43
Souris-Red Rainy	12	12	12	9	10	10	11	6	6	7	6	6	6	6
Missouri	89	86	88	78	84	89	93	55	53	53	46	50	53	55
Arkansas-White-Red	68	70	70	64	69	73	76	43	43	43	38	41	43	44
Texas Gulf	55	60	58	56	60	64	67	34	36	36	33	35	38	39
Rio Grande	11	11	11	11	12	12	13	6	6	7	5	6	7	7
Upper Colorado	3	3	3	3	3	3	3	3	3	2	2	2	2	2
Lower Colorado	7	8	8	9	10	10	11	4	5	5	6	6	7	7
Great Basin	7	8	1	7	7	8	8	4	5	4	4	5	5	6
Pacific Northwest	84	87	87	83	89	94	99	53	53	52	50	54	56	59
California	56	57	56	51	55	58	61	33	33	33	30	32	34	35
Alaska	4	4	4	5	5	6	6	2	3	3	3	3	3	3
Hawaii	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Caribbean	16	24	24	33	36	37	39	10	15	15	19	20	21	22
Total	2,092	2,321	2,317	2,401	2,591	2,727	2,868	1,290	1,408	1,394	1,436	1,526	1,595	1,658

Source: See source note table 7.1.

Table 7.8—*Fresh water withdrawals and consumption for commercial use in the United States in 1975, by water resource region, with projections of demand to 2030*

(Million gallons a day)

Water resource region	Withdrawals							Consumption						
	1975	1985	1990	2000	2010	2020	2030	1975	1985	1990	2000	2010	2020	2030
New England	361	393	407	442	474	506	537	48	52	54	58	62	67	71
Middle Atlantic	650	726	751	826	886	945	1,004	91	101	105	114	123	131	140
South Atlantic Gulf	553	632	654	769	825	880	935	118	138	144	161	173	185	198
Great Lakes	1,010	1,091	1,130	1,206	1,294	1,380	1,466	113	123	128	140	151	161	171
Ohio	495	529	548	571	613	653	694	62	67	70	74	80	85	91
Tennessee	90	102	107	116	124	133	141	11	12	12	14	15	16	17
Upper Mississippi	515	552	571	603	647	690	613	63	67	70	74	80	85	91
Lower Mississippi	150	159	165	170	182	194	207	49	51	53	54	58	62	66
Souris-Red Rainy	15	15	16	14	15	16	17	6	6	6	6	6	7	7
Missouri	285	306	317	336	360	384	408	69	72	74	78	80	82	84
Arkansas-White-Red	210	221	229	238	255	272	289	69	72	75	78	84	90	96
Texas Gulf	283	317	328	300	322	343	365	94	103	107	118	127	136	145
Rio Grande	62	65	67	68	73	78	83	30	31	32	32	34	37	39
Upper Colorado	10	10	10	11	11	11	12	3	4	4	4	4	5	5
Lower Colorado	75	92	95	114	122	130	138	35	43	45	54	58	62	66
Great Basin	38	45	47	55	59	63	67	17	19	20	22	24	25	27
Pacific Northwest	274	282	292	307	329	351	373	55	56	58	60	65	69	74
California	374	414	429	470	504	538	571	155	174	181	198	213	228	243
Alaska	7	9	9	10	11	11	12	1	2	2	2	2	2	2
Hawaii	29	36	37	46	49	53	56	11	12	12	15	16	17	18
Caribbean	44	52	54	60	64	69	73	9	11	11	13	14	15	16
Total	5,530	6,048	6,263	6,732	7,219	7,701	8,181	1,109	1,216	1,263	1,369	1,469	1,567	1,667

Source: See source note table 7.1

Table 7.9 — *Fresh water consumption in the United States in 1975, by major use, with projections of demand to 2030*

(Million gallons a day)

Major use	1975	1985	1990	2000	2010	2020	2030
Irrigation	86,391	92,820	91,011	92,506	95,395	100,290	99,972
Steam electric	1,419	4,062	6,583	10,541	14,376	17,674	21,373
Manufacturing	6,059	8,903	11,992	14,699	18,059	21,632	25,117
Domestic and commercial:							
Central	4,976	5,665	5,988	6,638	7,308	7,971	8,550
Noncentral	1,292	1,408	1,394	1,436	1,526	1,595	1,658
Commercial	1,109	1,216	1,263	1,369	1,469	1,567	1,667
Minerals	2,196	2,777	3,021	3,609	4,087	4,669	5,203
Livestock	1,912	2,233	2,275	2,551	2,825	3,095	3,316
Public lands and other	1,236	1,461	1,538	1,731	1,929	2,127	2,326
Total	106,591	120,545	125,065	135,080	146,974	160,620	169,182

Source: See source note table 7.1

future years. The rates of growth are expected to be largest in manufacturing (142 percent from 1975 to 2000) and steam electric cooling (643 percent). Greater use of recycling techniques, while reducing overall withdrawals, will increase consumptive use. For example, the use of cooling towers at steam electric plants will cause greater loss to evaporation than does once-through cooling.

Consumption by Region and Use

Major differences appear among water resource regions in the amount of water used consumptively. As expected, regions that irrigate heavily are also large water consumers. The largest consumptive use — 27 billion gallons a day — was in the California region, which accounts for about 25 percent of the total national consumptive use (table 7.3). The Missouri Basin was the second largest water consumer with 15.5 billion gallons a day, or 15 percent, and the Pacific-Northwest and Texas Gulf regions each accounted for more than 11 billion gallons a day, or about 11 percent. Total consumptive use is projected to increase to 135 billion gallons a day (26 percent) by the year 2000, but the interregional proportions are not likely to change very much.

The concentration of heavy consumptive use in the California, Missouri, Pacific-Northwest, Texas Gulf, and the Arkansas-White-Red regions reflects the large demands for irrigation water. For example, 91 percent of the consumptive use of 27 billion gallons a day in the California region is for irrigation—the proportion is 92 percent for the Missouri region.

Overall, consumptive use for irrigation is projected to increase by about 7 percent from 1975 to 2000 (table 7.3). The most significant change is expected in the Texas Gulf region, where consumptive use will decline by 34 percent from 9.3 to 6.1 billion gallons a day because ground water mining is depleting the water table and reducing the amount of ground water available. This suggests a potential decline in agricultural use in the High Plains area unless water supplies are increased or some other form of technology is adopted to bring consumptive uses in line with longrun annual supplies. The Rio Grande, Lower Colorado, and Great Basin will all show modest decreases in ground water consumed.

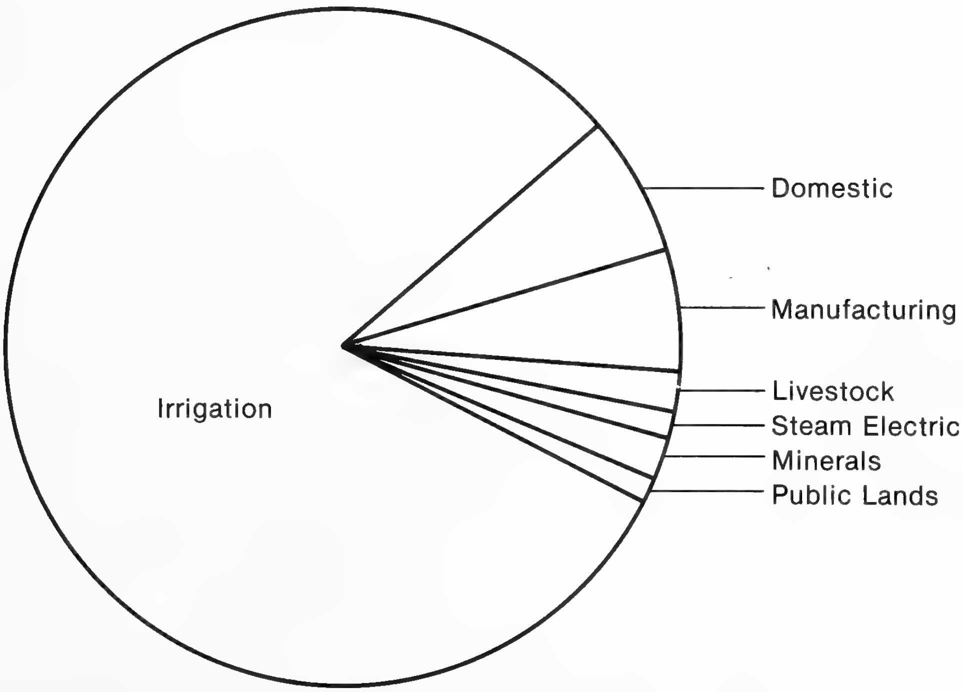
Water consumed in manufacturing processes is highest in the Great Lakes region, which accounts for nearly a quarter of manufacturing use. The Ohio, Middle Atlantic, South Atlantic Gulf, and Texas Gulf regions are also major consumers of manufacturing water. Consumptive use in manufacturing is projected to more than double by 2000 (table 7.5). This growth will likely be shared by nearly all regions, but those mentioned above will continue to be most important.

The most dramatic increase in water consumption will be in steam electric cooling, which is projected to increase from 1.4 billion gallons a day to 10.5 billion gallons a day by 2000. Consumptive use will increase in almost every region, but most significantly in the South Atlantic Gulf and the Lake States (table 7.4). This is almost entirely due to the shift from once-through cooling to cooling towers to minimize thermal pollution. Other types of consumptive use are projected to increase, but at a slower rate.

Irrigation is the largest use of water, accounting for more than 80 percent of total consumption.

Figure 7.3

Water Consumption by Major Use in the United States, 1975



Instream Uses

Not all uses require removing water from its source. Many uses depend on the amount of water that remains in the water course itself. These include hydroelectric power generation, navigation, water-based recreation, and flow requirement for aquatic habitat.

In 1975, hydroelectric power supplied approximately 15 percent of the total national electric power production. Conventional hydroelectric plants are projected to generate only about 6 percent more electricity in 2000 than in 1975. However, as alternative costs increase, hydropower generation may be viewed with increasing interest. Hydroelectric power plants produce power without consuming fossil fuels, without polluting water or air, and without creating possible radiation hazards. These plants have long lives, low operating costs, and low outage rates. Two disadvantages are the high construction costs and potential interruption of free-flowing streams.

The Nation's rivers and lakes have served as avenues for public and commodity transportation from the time of the earliest inhabitants. Since about 1770, the extent and capacity of inland and intracoastal waterway systems have continually increased to the point where they now include more than 25,000 miles of navigable channels, canals, and reservoirs.

Total domestic waterborne traffic increased from 829 million tons in 1965 to about 1,000 million tons in 1974. By the year 2000, about 1,500 million tons are expected. Almost all of this will be bulk goods, such as coal, grain, crude oil, and other petroleum products. In 1974, waterborne commerce was about one-fourth of the total intercity freight measured in ton miles.

Streamflows are also needed to support outdoor recreation activities and fishery habitats for commercial fisheries. A discussion of flows and flow requirements at the national, or even regional level, tends to obscure water problems that might surface from analyses in local areas. For example, it has been computed that nationally flows of 1,040 billion gallons a day would be ideal to support fishery requirements. The average national flow is 1,242 billion gallons a day. Unfortunately, not all regions and subregions share equally in the average annual flow.

In a subsequent section of this chapter, the adequacy of supplies to support fisheries will be analyzed in terms of a depletion analysis. The criteria for this analysis will also be discussed.

Bulky products such as oil, coal, wheat, and chemicals are efficiently transported on waterways.

The Supply of Water

In an average year, about 40 trillion gallons a day pass over the conterminous United States as water vapor. About 10 percent is precipitation in the form of rain, snow, sleet, or hail, which equals an average annual amount of 30 inches nationwide. About two-thirds of this precipitation returns to the atmosphere via evaporation and transpiration. The remaining 1.4 trillion gallons a day of precipitation (average of 9 inches) flows to the ocean or across U.S. boundaries, accumulates in storage, or is consumptively used.

Precipitation is enough to meet current and projected needs if it were available for use where and when needed. However, there is wide variation in precipitation by region. The normal annual precipitation over the contiguous States generally ranges from an average of less than 4 inches in parts of Great Basin and Lower Colorado regions to more than 200 inches in coastal areas of the Columbia-North Pacific Region (fig. 7.4). There are specific localities that even fall outside this range. About 26 inches of the total of 30 is from rainfall; the remainder is snow or other frozen form. The area east of the Mississippi River averages about 18 inches. In the Alaska region, the normal annual precipitation ranges from about 5 inches in the extreme north to more than 200 inches in the southeast, with a State average of about 20 inches.

A large portion of the precipitation in the United States falls on forested land because forests are typically located at higher elevations, initially capturing and gradually releasing water to downstream areas. Also, forest and range vegetal cover usually provides excellent protection for streams because it maintains good water quality and helps stabilize flow.

Just as precipitation varies greatly from place to place, season to season, and year to year, so do runoff and streamflow. For example, even in a normal year, the ratio of maximum flows to minimum flows may be 500 to 1 or greater. As a result, adverse impacts of drought are intensified, especially in areas that use a high proportion of normal streamflow or where storage is minimal. The range in variation in streamflow in the humid East tends to be less from year to year and from month to month than in other regions. Average annual runoff based on data from 1931 to 1960 is shown in figure 7.5. More than 60 percent of the annual runoff originates on forest lands, which comprise about one-third of the total land area. In the 11 Western States, more than 90 percent of the usable precipitation originates on high-altitude watersheds, which are typically forested.

In 1975, the conterminous United States withdrew a total of 393 billion gallons per day from surface and ground sources. Of this total, 254 billion was from fresh surface water sources, 58 billion from saline surface sources, and 81 billion gallons per day from ground water. Surface and ground sources are generally highly interactive; consequently, significant impacts upon one is likely to affect the other.

Water supply problems stem from the high variation in both the geographic and temporal distribution of water. Some regions have an abundance of water, while others receive very little precipitation. Still others have problems because precipitation largely occurs during certain seasons so that other parts of the year are very dry. Only a small portion of the potential 1.4 trillion gallons a day can be developed for intensive use.

The temporal problem can often be reduced through storage, either in reservoirs or as ground water. Total reservoir storage capacity in the United States is about 700 million acre-feet; about 35 percent of this capacity was built for flood control and the remainder for water supply, hydropower, recreation, fire protection, and esthetics value.

It is estimated that 100 billion acre-feet of ground water is within 2,500 feet of the surface in the conterminous United States, about 50 percent of this volume is economically and environmentally available. This amount is nearly 150 times the amount of our total reservoir storage capacity, or more than the Mississippi River has discharged into the Gulf of Mexico over the last 200 years. About half of the country is underlain by rock material that could yield at least 50 gallons per minute from wells.

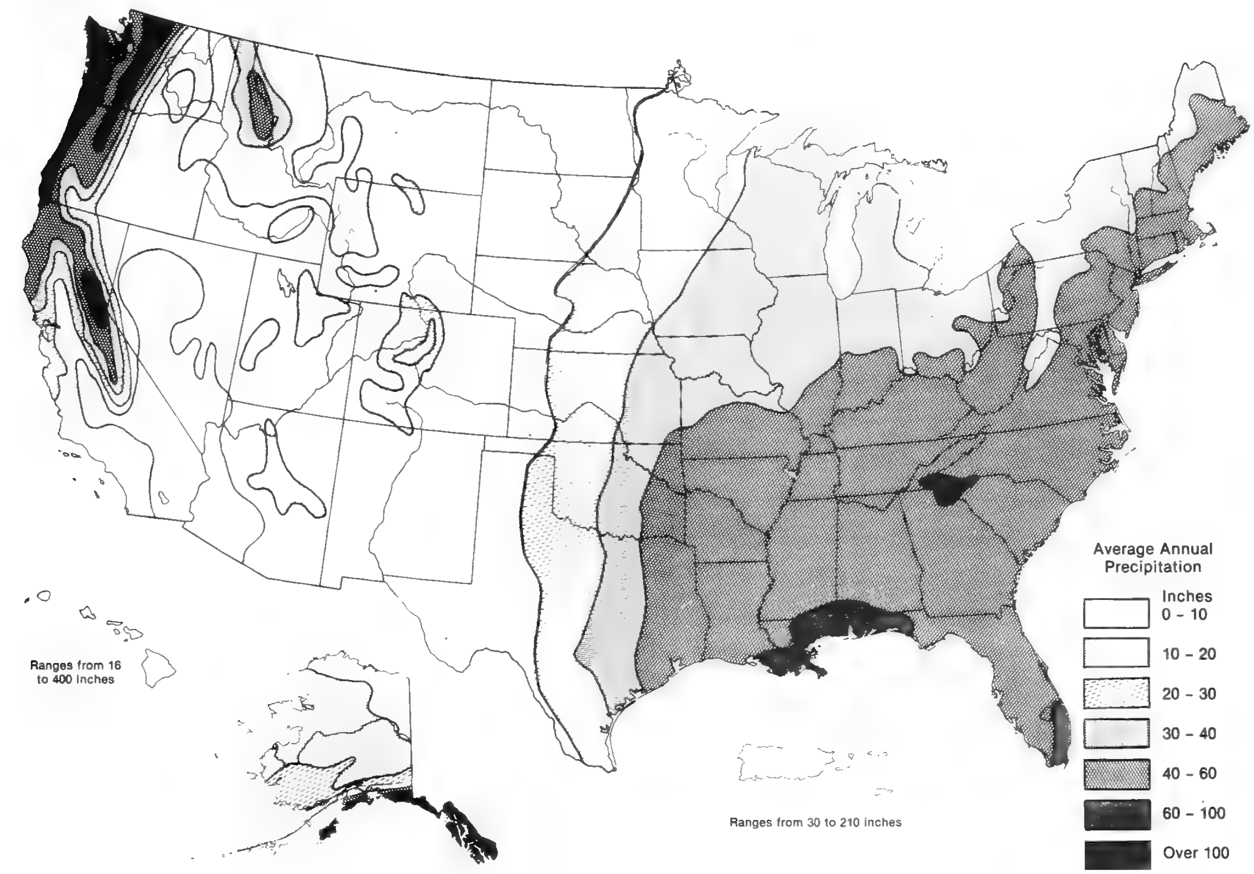
Ground water also provides the base flow of streams; in some regions, ground water flows provide streams with a continuity of flow that they would not otherwise possess. The water supply information presented in the section on surface water includes considerable water that enters from ground water aquifers. Part of this ground water resource does not get into surface water supply naturally, and can be developed only by drilling.

The Atlantic and Gulf Coastal Plains contain the largest reserve of ground water in the Nation (fig. 7.6). Present pumpage is but a small fraction of the supplies that could be developed. Even so, salt-water encroachment along the Gulf and Atlantic coasts is a limiting factor in ground water development.

It is estimated that 100 billion acre-feet of ground water is within 2,500 feet of the surface in the conterminous United States; about 50 percent of this volume is economically and environmentally available. This amount is nearly 150 times the amount

Figure 7.4

Average Annual Precipitation



of our total reservoir storage capacity, or more than the Mississippi River has discharged into the Gulf of Mexico over the last 200 years. About half of the country is underlain by rock material that could yield at least 50 gallons per minute from wells.

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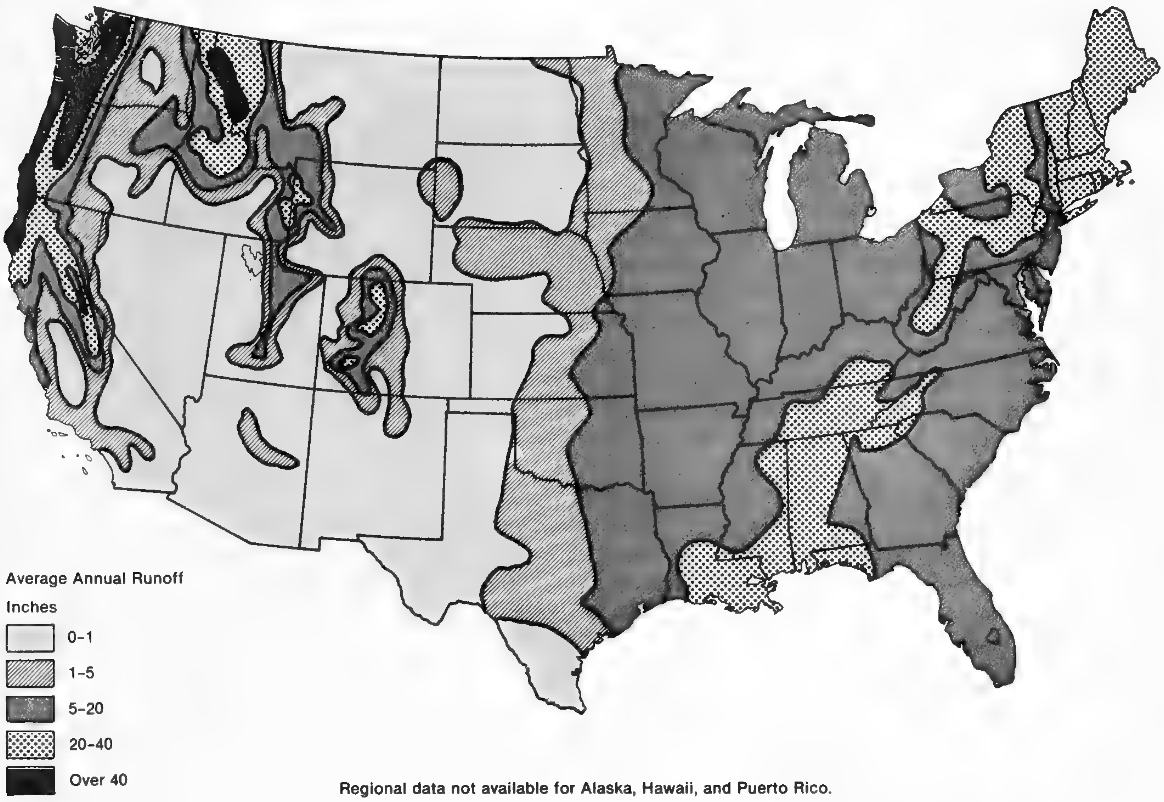
The Atlantic and Gulf Coastal Plains contain the largest reserve of ground water in the nation (fig. 7.6). Present pumpage is but a small fraction of the supplies that could be developed. Even so, saltwater encroachment along the Gulf and Atlantic coasts is a limiting factor in ground water development.

Another significant area for ground water potential is the series of alluvial basins in the West. These are alluvium-filled valleys that receive runoff recharge from surrounding mountains. The surface is very dry, but the alluvial deposits are usually very thick and they now store the equivalent of centuries of charging. In this area, conjunctive development of streamflow and ground water in storage is becoming a necessity because of heavy water use for irrigation and domestic needs in large cities such as Los Angeles, Phoenix, and Albuquerque.

Figure 7.5

Average Annual Runoff



Regional data not available for Alaska, Hawaii, and Puerto Rico.

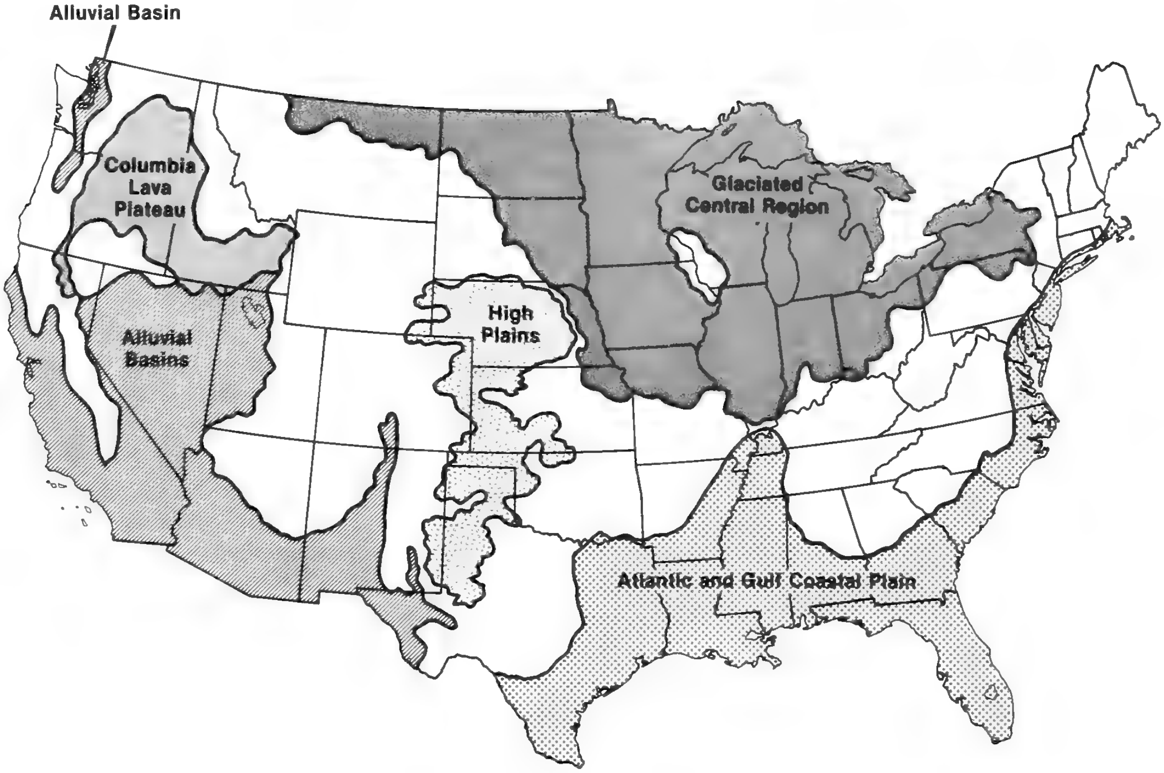
Still another area with important ground water potential is that of the glacial deposits in the Great Lakes area, extending from central Montana to eastern New York. The deposits contains beds of water-sorted permeable sand and gravel but constitute an important source of water.

Ground water supplies become depleted if recharge of ground water aquifers does not equal or exceed withdrawals. Because mining is substantial in some areas of the nation, ground water levels have been receding rapidly. For example, more than 14 million acre-feet are mined annually in the High Plains area. Thus, much of the nonrenewable ground water in parts of the arid West is being exhausted at a rate that will cause significant reductions in total availability by the year 2000.

The water supply available for use in a region is the runoff into streams or other water bodies augmented by the contribution of ground water to streamflows, plus the amount that is available directly from ground water aquifers on a long-term basis. This supply can be calculated for a region by measuring the flow of streams as they leave the region, adding the volume of water consumed in the region, and subtracting the volume of ground water depletion, or the volume of mined ground water. Table 7.10 presents a general picture of the Nation's water supply by water resource region. This is the supply expected in a year of average precipitation; 80 years out of 100; and 95 years out of 100. This should closely approximate an annual supply based on the stated probabilities of occurrence.

Figure 7.6

Major Areas of Potential Groundwater Development



Regional data not available for Alaska, Hawaii, and Puerto Rico.

In most regions, water supplies vary from high flows during spring and early summer to low flows during late summer to early winter. Many times the high water-use season corresponds to the low water-yield season. For this reason, analysis of average water supplies and demands does not reveal some water shortage problems. Although the Nation's total streamflow varies greatly from year to year, the longterm trend shows that the flow has been remarkably constant and that no general or persistent downward trend is evident, though the 10-year moving average indicates rather prominent swings of a near-periodic nature (fig. 7.7).[4]

[4] Langbine, Walter B. Water resources review for December 1977. U.S. Department of the Interior, Geological Survey. 18 p. 1978.

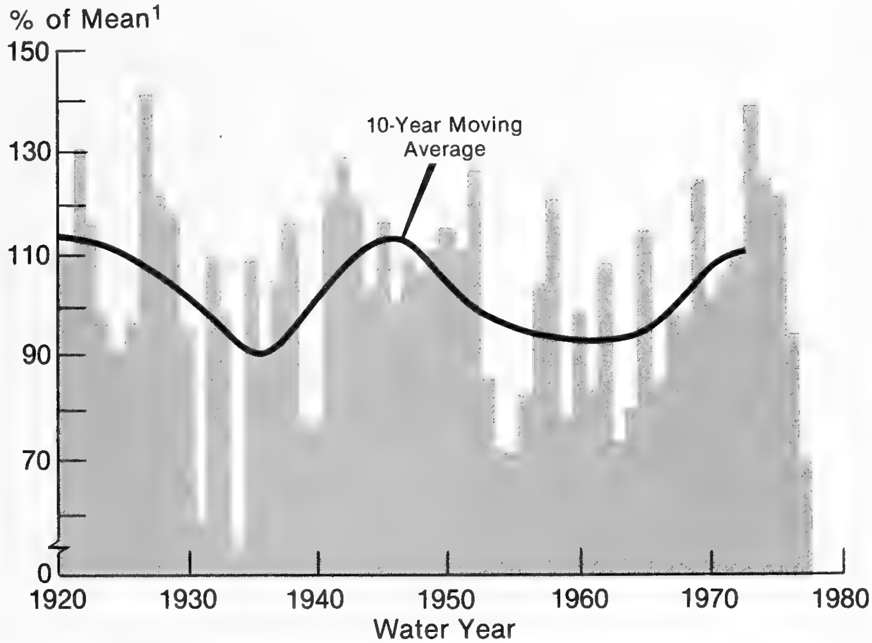
Problem Areas

A comparison of water supply and demand data shows that the Nation's water supplies are generally sufficient to meet water needs for all purposes. However, major problems are evident in most of the 21 water resource regions; more particularly, there are serious local problems in nearly all of the 106 subregions. These include shortages resulting from poor distribution of supplies, instream-offstream conflicts, competition among various offstream users, ground water overdrafts, quality degradation of both surface and ground water supplies, and institutional conflicts that prevent a unified approach to water management.

To better relate potential water supply problems to the Resources Planning Act Regions used in this report, the subregions have been reaggregated to represent the Resources Planning Act Regions as closely as possible.

Figure 7.7

Annual Mean Streamflow within the United States, 1930-1976, and the Moving Average, 1920-1974



[1]Computed from base period 1931-1960.

Water Quantity

Table 7.11 presents the water demand-supply data used to evaluate water supply adequacy. The proportion of each subregion that is currently in forest and range is presented to indicate the relative importance of forest and range management to each subregion. In the analysis of water quantities, two levels of supply are considered: (1) The mean supply, which is the amount of water that would be expected in the average water supply year, and (2) the dry year supply, which is the minimum amount that is expected 80 years out of 100. In effect, the expected water supply will be less than the dry year supply 20 percent of the time.

Consumptive water use is one of the more important factors to consider in evaluating water adequacy. Table 7.11 shows the percentage depletion of supplies, which is the proportion of the available supply that will be consumptively depleted in the mean and dry years.

Figures 7.8 and 7.9 also present the 106 Water Resource subregion by four water depletion categories based upon the highest depletion rate over time in the mean water supply year (fig. 7.8) and the dry supply year (fig. 7.9).

Often, seasonal water supply problems are not apparent from annual supply-use data. Therefore, table 7.11 also presents the number of months each year in which consumptive use would exceed the 90 percent supply in both the mean and dry supply years. This indicates the importance of seasonal variations, and also will have important implications for instream uses which will be discussed later.

It is important to note that in some subregions, ground water mining is used to supplement surface flows. Thus, the monthly data represent the situation if ground water mining does or does not occur. For example, table 7.11 shows that in the average supply year for the San Joaquin-Tulare Subregion (1803), consumptive use normally will exceed 90 percent of streamflow for 4 months without mining ground water, and only for 3 months if ground water mining continues. Mining is only a temporary solution to water supply problems and cannot continue indefinitely.

Table 7.10 — *Expected water supplies in the United States, by water resource region*

(Billion gallons a day)

Water resource region	Confidence level[1]		
	Mean	80 percent	95 percent
New England	78.2	62.7	48.3
Middle Atlantic	79.2	61.2	48.4
South Atlantic Gulf	228.0	164.1	121.8
Great Lakes	72.7	57.3	44.9
Ohio	178.0	141.0	105.0
Tennessee	40.8	35.9	31.4
Upper Mississippi	121.0	91.8	65.3
Lower Mississippi	433.0	282.0	202.0
Souris-Red Rainy	6.0	3.4	1.8
Missouri	44.1	29.9	17.6
Arkansas-White-Red	62.6	37.4	21.6
Texas Gulf	28.3	12.3	6.3
Rio Grande	1.2	.3	.2
Upper Colorado	10.0	7.0	3.9
Lower Colorado	1.6	1.4	1.2
Great Basin	2.6	1.6	1.2
Pacific Northwest	255.3	213.3	179.7
California	47.4	29.8	19.5
Alaska	905.0	795.0	705.0
Hawaii	6.7	4.9	3.8
Caribbean	4.9	3.3	1.6

[1] The quantity of water supply expected annually on the average and at 80 and 95 percent probability level.
Source: See source note table 7.1

In general, the eastern United States is expected to have few water shortage problems at the subregion level. The Northeast region has no subregions where water quantity problems are anticipated during the projected years. Nor does there appear to be major seasonal problems since consumptive use does not exceed 90 percent of the supply in any month (table 7.11). Yet, in the early 1960's, the Northeast region experienced a drought that had a severe impact on supplies. Such problems could be expected to occur again, though infrequently (less than 10 out of 100 years).

Within the North Central region, water quantity problems are most likely in the Southwestern Lake Michigan subregion (0403). The dry year supply will be depleted by 55 percent by 1985 and by 80 percent by 2000. The 95 percent supply (1 in 20 years) would fall considerably below annual consumption needs. A small increase in demand in combination with drought conditions could amplify the problem. Manufacturing and electric cooling will be major water consumers in this subregion, and would likely be most severely affected in a drought year.

In the Southeast Region, only the Southern Florida (0305) subregion in the South Atlantic Gulf is likely to experience significant flow depletion. It is significant that in 20 percent of the years, streamflow will be depleted in excess of 90 percent for 5 months. This shows a serious seasonal supply problem, and could represent a substantial problem for instream values.

Within the South Central region, several subregions show potential depletion problems. The Canadian (1105) and the Red-Washita (1106) subregions have only moderately high depletion rates, but their water supply problem is critical because of the high rates of ground water mining. In the Canadian subregion (1105), ground water mining accounts for 68 percent of the average year supply. The monthly analysis shows a large difference in the number of months that consumptive use exceeds 90 percent supply with and without ground water mining.

Also in the South Central, the Brazos (1203) and the Colorado (1204) subregions show high depletion ratios, especially in the dry years, though they currently exceed 50 percent depletion in the average year. More than half of the months show an excess of 90 percent depletion during the dry year in these two subregions. In much of the High Plains area, irrigation is heavily supported by ground water mining, which supplies 39 percent and 24 percent of the average supply in subregions 1203 and 1204, respectively. A water shortage in the future could severely affect the economy of the South Central Region, which is heavily dependent on irrigated agriculture. Both the Rio Grande-Pecos (1303) and the Lower Rio Grande (1305) are likely to experience major depletions, the latter exceeding 90 percent in all dry years.

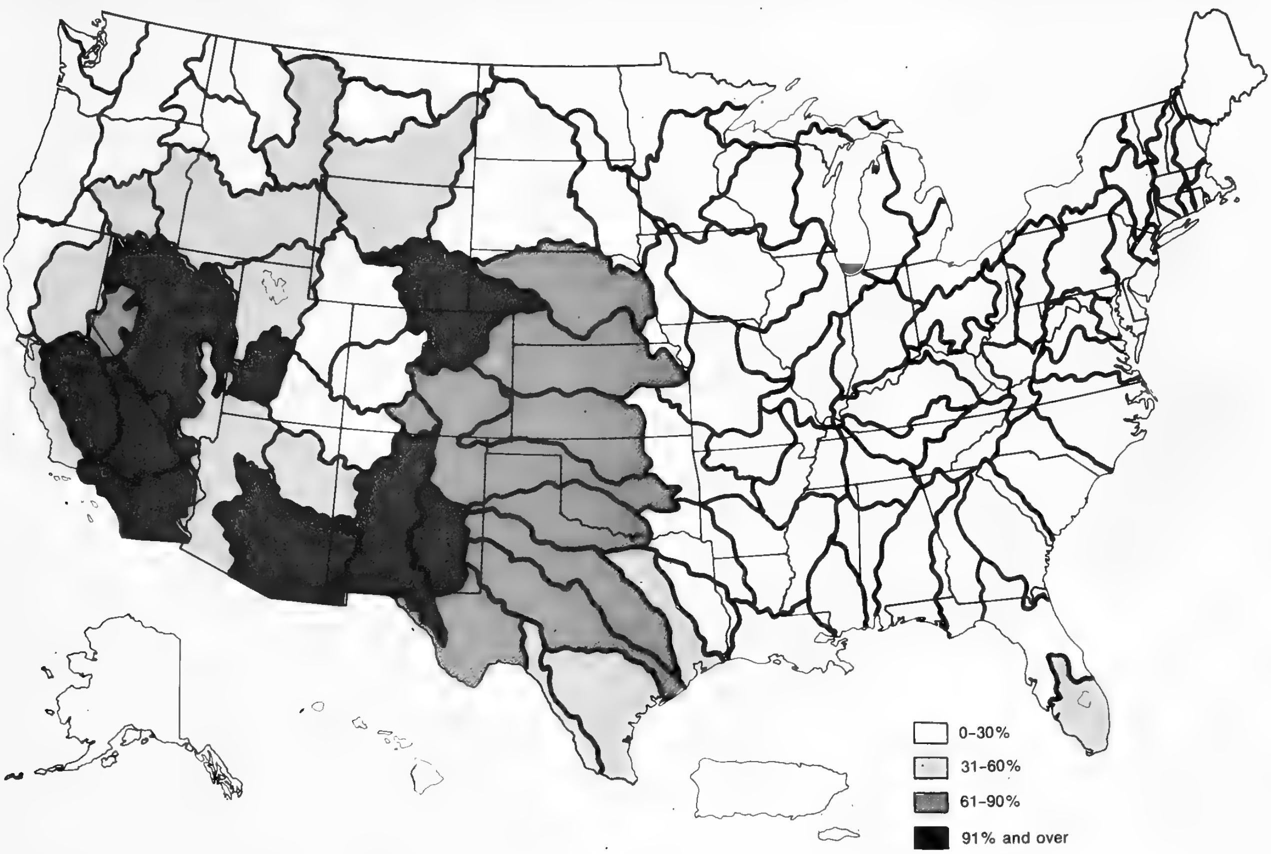
The Great Plains region includes four subdrainages in the Missouri River Basin and one in the Arkansas-White-Red River Basin. The Niobrara-Platte-Loup (1008), Kansas (1010), and the Arkansas-Cimarron (1103) all show high depletions currently ranging from 58 to 113 percent in the dry year. Irrigation accounts for more than 90 percent of the water consumed in these subregions; consequently, the agricultural economy will be impacted the greatest in years of short supply. Ground water overdraft is fairly significant in the Kansas and Arkansas-Cimarron drainages.

The Rocky Mountain Region, which includes parts of the Missouri, Rio Grande, Colorado, Great Basin, and the upper drainages of the Columbia Rivers, has several subregions that have potential water quantity problems. These are discussed as part of the major drainages.

In the Missouri River portion of the Rocky Mountain Region, the No/So Platte (1007) will approach 90 percent depletion in any dry year. The No/So Platte is experiencing seasonal water shortages and is mining large amounts of ground water. Irrigation, which accounts for more than 90 percent of consumption, will be impacted most during years of short

Figure 7.8

Highest Percentage Water Depletion (1975-2000) in a Mean Water Supply Year, by Water Resource Region



supply. The Upper Arkansas (1102) has one of the highest depletions in the Nation—119 percent in a dry year.

The Rocky Mountain Region contains three of the Rio Grande subregions, all of which have very high depletion rates. Both the Rio Grande Headwaters (1301) and Upper Pecos (1304) would now exceed 100 percent depletion in the dry year. The Gila (1503) consumes 99 percent of the average supply, of which 66 percent is mined ground water. All of these subregions are 60 to 70 percent forest and range, indicating that resource management may offer at least partial solution.

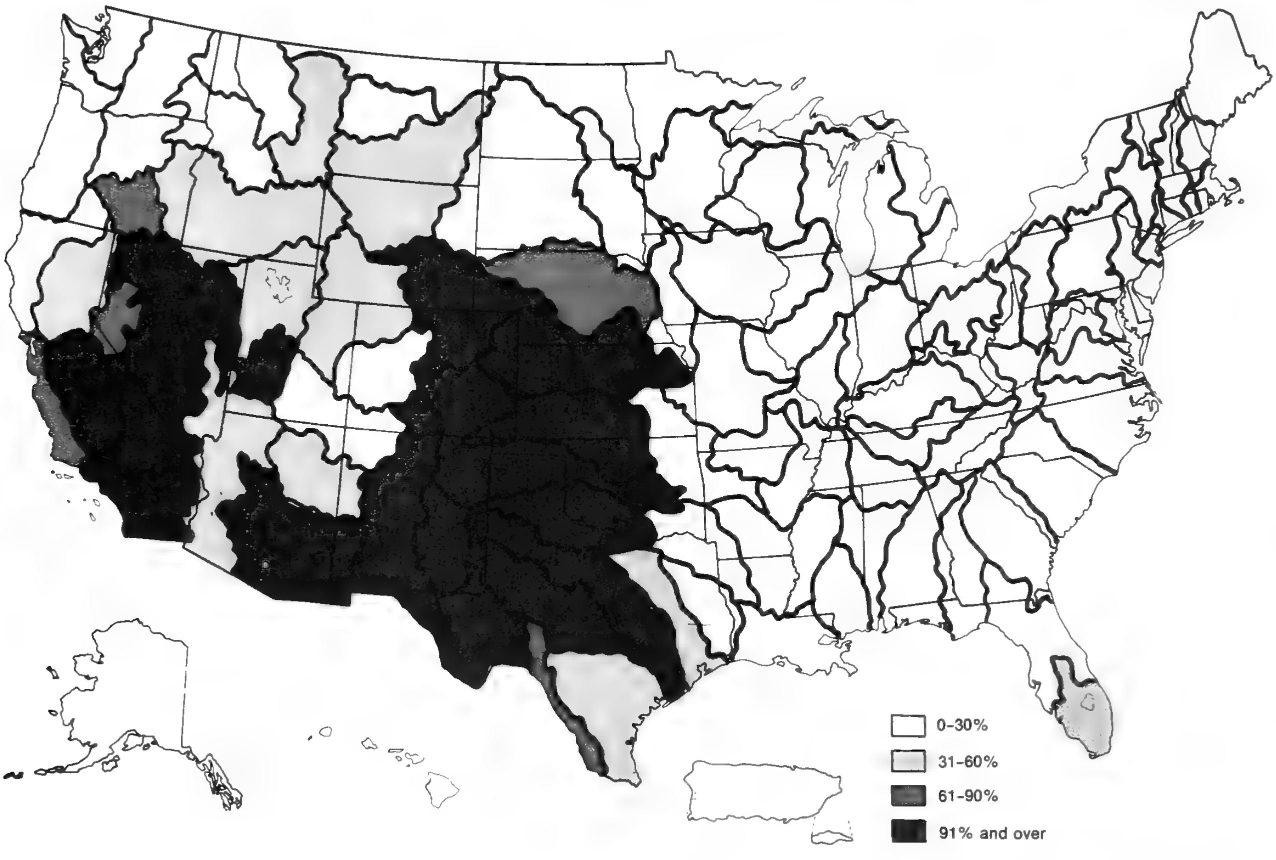
Overall, the Great Basin drainages show very high depletion rates. Water consumption in the Humboldt-Tonopah (1603) would exceed the available supply by 17 percent in a dry year, and will exceed 100 percent of supply by 1985 in the average supply situation. Because of heavy irrigation use in these basins, the seasonal distribution is a problem. Depletion exceeds 90 percent supply several months every year.

The Pacific Coast Region consists of the lower portion of the Columbia River and all of the California-South Pacific Water Resource Region. Several subregions show significant potential problems, including the Oregon Closed Basin (1707), San Joaquin-Tulare (1803), Central California (1805), Southern California (1806), and the Lahontan-South (1807). Several others show moderately high depletion.

In all of these areas where water shortages are expected, excluding the Great Lakes region, irrigated agriculture is the major consumptive water use. Water values for irrigation are among the lowest of all withdrawal or consumptive uses. As water becomes scarce, its use will ultimately decline for those purposes of lower value. Thus, it is evident that the water shortages enumerated will ultimately have the greatest direct impact on the agricultural and related economy.

Figure 7.9

Highest Percentage Water Depletion (1975-2000) in a Dry Water Supply Year, by Water Resource Region



At present, water quantity problems are of little consequence in Alaska, nor are they expected in the future. Consumption of water in Hawaii is increasing, but is not expected to pose serious supply problems. Water consumption in the Virgin Islands will greatly exceed water supplies in the future, but this is not the case in Puerto Rico.

Adequacy of Instream Flow

The "depletion" analysis can also provide information about the adequacy of waterflows to support aquatic life. To do this, it is necessary to establish criteria for describing the severity of various levels of depletion. Tennant[5] has described the instream flow conditions for 60 (40 percent depletion), 30 (70 percent depletion), and 10 percent (90 percent depletion) mean annual flow.

"Sixty percent of average flow (40 percent depletion) is the base flow recommended to provide excellent to outstanding habitat for most aquatic life forms during their primary periods of growth and for the majority of recreational uses. Channel widths, depths, and velocities will provide excellent aquatic habitat. Most of the normal channel substrate will be covered with water, including many shallow riffle and shoal areas. Side channels that normally carry water will have adequate flows. Few gravel bars will be exposed, and the majority of islands will serve as wildlife nesting, denning, nursery, and refuge habitat. The majority of streambanks will provide cover for fish and safe denning areas for wildlife. Pools, runs, and riffles will be adequately covered with water and provide excellent feeding and nursery habitat for fishes. Riparian vegetation will have plenty of water. Fish migra-

[5] Tennant, Donald L. Instream flow regimens for fish, wildlife, recreation and related environmental resources. U.S. Department of the Interior, Fish and Wildlife Service, Billings, Montana, 123 p. 1975.

There are very high water depletion rates in the Great Basin drainages in the Rocky Mountains. Storage ponds can supplement water supplies.

tion is no problem in any riffle areas. Water temperatures are not expected to become limiting in any reach of the stream. Invertebrate life forms should be varied and abundant. Water quality and quantity should be excellent for fishing and floating canoes, rafts, and larger boats, and general recreation. Stream esthetics and natural beauty will be excellent to outstanding.

"Thirty percent of the average flow (70 percent depletion) is a base low recommended to sustain good survival habitat for most aquatic life forms. Widths, depths, and velocities will generally be satisfactory.... The majority of the substrate will be covered with water, except for very wide, shallow riffle or shoal areas. Most side channels will carry some water. Most gravel bars will be partially covered with water and many islands will provide wildlife nesting, denning, nursery, and refuge habitat. Streambanks will provide cover for fish and wildlife denning habitat. Many runs and most pools will be deep enough to serve as cover for fishes. Riparian vegetation will not suffer from lack of water. Large fish can move over riffle areas. Water temperatures are not expected to become limiting in most stream segments. Invertebrate life is reduced but not expected to become a limiting factor in fish production. Water quality and quantity should be good for fishing, floating, and general recreation, especially with canoes, rubber rafts, and smaller shallow draft boats. Stream esthetics and natural beauty will generally be satisfactory.

"Ten percent of the average flow (90 percent depletion) is a minimum instantaneous flow recommended to sustain short-term survival habitat for most aquatic life forms. Channel widths, depths, and velocities will all be significantly reduced and the aquatic habitat degraded. . . . The stream substrate or wetted perimeter may be about half exposed, except in wide, shallow riffle or shoal areas where exposure could be higher. Side channels will be severely or totally dewatered. Gravel bars will be substantially dewatered, and islands will usually no longer function as wildlife nesting, denning, nursery, and refuge habitat. Streambank cover for fish and fur animal denning habitat will be severely diminished. Many wetted areas will be so shallow they no longer will serve as cover, and fish will generally be crowded into the deepest pools. Riparian vegetation may suffer from lack of water. Large fish will have difficulty migrating upstream over many riffle areas. Water temperature often becomes a limiting factor, especially in the lower reaches of streams in July and August. Invertebrate life will be severely reduced. Fishing will often be very good in the deeper pools and runs since fish will be concentrated. Many fishermen prefer this level of flow. However, fish may be vulnerable to overharvest. Floating is difficult even in a canoe or rubber raft. Natural beauty and stream esthetics are badly degraded. Most streams carry less than 10 percent of the average flow at times, so even this low level of flow will occasionally provide some enhancement over a natural flow regime."

From the established criteria, it can be determined that depletion levels in excess of 90 percent for sustained periods usually will have serious adverse effects on aquatic habitat. The monthly analysis in table 7.11 indicates those subregions where the flow will be reduced by more than 90 percent for long periods.

Most of the major impacts of use on the volume of water in streams occurs in the West (table 7.11). These data, however, provide comparisons only of total water consumption in a subregion with the average outflow of water from the subregion. Most regions and subregions have main streams and tributaries that have flows well below the "good survival habitat" level at some time during a normal year, and many also approach or go below the "minimum short-term survival" flow level. In some cases, including some in the western United States, natural streamflows are augmented by reservoir releases to avoid such problems.

There are other cases, however, where streamflows fluctuate widely during the day in response to reservoir discharges to meet varying demands for hydroelectric power. Average flows seem adequate for aquatic life in Water Resource Regions 1-9. High depletions are causing the greatest instream impacts on aquatic life in the Rio Grande region and the Lower Colorado and the Southern California subregions. Other areas under stress include the No/So Platte, parts of the Arkansas-White-Red region and the Brazos, Colorado, San Joaquin, and the San Francisco Bay subregions. In a dry year, additional aquatic habitat areas that are likely to be greatly impacted include the Southern Florida and Kansas

regions, and most of the Arkansas-White-Red and the Great Basin regions.

Major efforts have been made — by construction of reservoirs and channel dredging — to maintain instream flow levels that are sufficient for commercial navigation on the inland waterways system. While mitigating the effects of variable rainfall on the acreage level of instream flows, these efforts have greatly modified aquatic habitat conditions. Water depths and movement have been changed on long stretches of many streams. At the same time, new habitat has been created in reservoirs.

The effect of forests and other vegetation on runoff and streamflows, especially in reducing wide variations in flow, has long been known. Increasing attention is being directed at nonstructural methods, including vegetation management, as alternatives to dams and channelization for minimizing wide swings in streamflows.

Flooding

Flooding affects all parts of the United States — in arid as well as humid areas. In 1975, despite modern communications and weather services, 113 people were killed by floodwaters, and property damages were estimated at $3.4 billion. Almost half of all flood damages are to agriculture, as crops and livestock are destroyed and production land is covered or washed away. In urban areas, property damage is accompanied by unemployment and dislocation of people.

The impact of flooding on wildlife, fish, and ecosystem is mixed. In upstream areas, wildlife food and habitat are often washed away or covered by floodwaters, resulting in severe damage to natural systems. Less measurable losses include funds spent for relief and reconstruction, lost productivity, and the general disruption of the economy during and after a flood. However, flooding may transport beneficial nutrients that improve or supply natural downstream systems.

Since 1941, annual flood damages have not been less than $50 million. Yearly damages usually range from $100 million to $400 million. Damages approaching $1 billion have occurred several times since 1950, the highest being $4.5 billion in 1972. Despite the increasing trend in annual flood damages, there is no evidence that storms are increasing in magnitude or frequency. The increases in damage result from inflation and, more importantly, from new development in flood-prone or flood-susceptible areas.[6]

[6] U.S. Water Resources Council. The 1975 assessment of water and related land resources, *op. cit.*

Average annual flood damage per square mile varies considerably by region and subregion (fig. 7.10). This wide variation in average flood damages is related in part to weather patterns, in part to the character of the streams in the region or subregion, and in part to the average value of property subjected to flooding.

Floods cause serious health problems, injuries, exposures, stress, and bacterial contamination. Many of these problems may continue long after the flood has subsided. The yearly loss of life from floods has usually been less than 100, but it exceeded 500 in 1972.

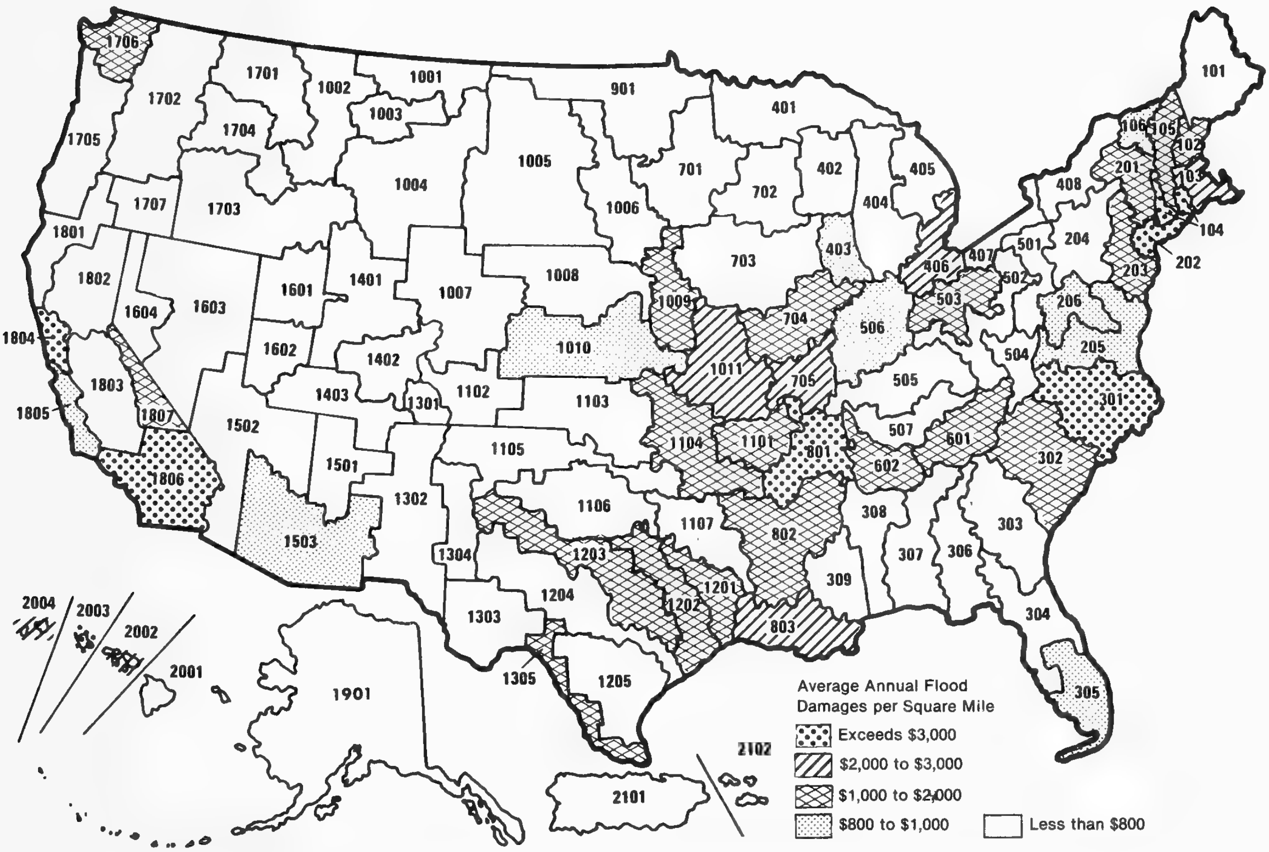
Floods can be both devastating or beneficial to agricultural interests. They can wipe out crops and dump tons of sand, gravel, clay, and other debris on productive lands. Floatable debris in flood plains can cause significant damage to structures such as bridges, culverts (and associated roads), and other structures within the flood plain, particularly for floods with recurrence intervals of up to 25 years. Loose materials that are picked up and carried by floodwaters are often trapped against structures such as bridges where they collect and form debris dams. These dams force water to find an alternate route around them. If the debris dams break loose and wash out, the resulting surge of water and debris can cause additional damage to other downstream structures and possible loss of life. On the positive side, slow-moving floods can deposit fertile, highly productive soil on cropland. Other types of enrichment can be found in wetlands and other natural areas where periodic flooding can rejuvenate feeding and breeding areas.

It is projected that average annual flood damages will increase to $4.3 billion in the year 2000. Agricultural damages are expected to be more than $1.7 billion in 2000 while urban damages are projected to increase by 36 percent to $1.6 billion. All other damages are expected to average about $1 billion. The annual loss of lives has varied widely over the years; consequently, no estimates were projected.

Generally, the regional estimates and projections of flood damages are closely correlated with population densities. The highest damages are likely to occur in the South Atlantic-Gulf, California, and Missouri regions. Agricultural damages are most important in the South Atlantic-Gulf and Missouri regions, but are also significant in the Upper and Lower Mississippi, Arkansas-White-Red, and the Texas Gulf regions. Urban damages will be more prominent in California, New England, Mid-Atlantic, and the Great Lakes regions.

Figure 7.10

Average Flood Damages by Subregion



Agriculture losses to flooding, such as this alfalfa field (left) and apple orchard (right), will account for 40 percent of flood losses by 2000.

Table 7.11—*Fresh water supply, percentage depletion (current and projected) in average and dry year, and number of months consumptive use exceeds 90 percent depletion in average and dry years in the United States, by region and subregion*

Resource Planning Act region and water resource subregion	Percent of area in forest and range	Water supply		Percentage depletion[3]										Number of months that 1975 consumptive use would exceed 90% supply			
		Mean[1]	Dry[2]	1975		1980		1985		1990		2000		With ground water[4] mining		Without ground water[4] mining	
				Mean	Dry	Mean	Dry	Mean	Dry	Mean	Dry	Mean	Dry	Mean	Dry	Mean	Dry
		Million gallons per day		*Percent*		*Percent*		*Percent*		*Percent*		*Percent*		*Number*		*Number*	
Northeast																	
0101 Northern Maine	88	37,988	31,088	2	3	3	4	4	5	5	6	7	8	0	0	0	0
0102 Saco - Merrimack	83	9,925	7,855	4	4	4	4	4	5	4	6	5	7	0	0	0	0
0103 Mass - Rhode I - Coastal	57	4,726	3,946	3	3	3	4	4	5	4	5	5	6	0	0	0	0
0104 Housatonic - Thames	66	4,858	3,698	2	2	2	2	2	3	2	3	3	4	0	0	0	0
0105 Connecticut River	79	12,520	9,880	1	1	1	1	1	1	2	2	3	3	0	0	0	0
0106 Richelieu	72	8,644	6,744	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0201 Upper Hudson	64	12,331	9,311	1	1	1	1	1	2	1	2	2	3	0	0	0	0
0202 Low Hudson - Li - NNJ	23	16,086	11,886	3	4	3	4	4	5	4	5	4	6	0	0	0	0
0203 Delaware	48	16,289	12,789	4	5	4	5	5	6	5	7	6	8	0	0	0	0
0204 Susquehanna	59	24,760	20,260	1	1	1	1	1	2	1	2	2	3	0	0	0	0
0206 Potomac	51	8,923	6,663	1	2	1	2	2	3	3	4	4	5	0	0	0	0
0408 Lake Ontario	50	18,119	14,619	1	1	1	1	1	1	1	2	2	3	0	0	0	0
0501 Ohio Headwaters	68	19,880	17,080	1	1	1	1	1	1	1	1	1	2	0	0	0	0
0504 Kanawha	72	10,811	8,901	1	1	1	1	2	2	2	3	3	4	0	0	0	0
Annual total		205,860	164,720	1	2	1	2	2	2	2	2	2	3				
North Central																	
0401 Lake Superior	89	9,892	8,022	1	2	1	2	2	2	2	2	3	3	0	0	0	0
0402 NW Lake Michigan	56	9,655	7,455	2	2	2	2	2	3	3	4	4	5	0	0	0	0
0403 SW Lake Michigan	6	1,784	1,394	31	40	37	47	43	55	50	63	63	80	0	0	0	0
0404 E Lake Huron	39	14,934	12,634	2	2	2	2	2	3	2	3	3	4	0	0	0	0
0405 Lake Huron	49	7,293	5,613	1	1	1	1	2	2	2	3	3	4	0	0	0	0
0406 St. Clair - W Lake Erie	11	7,890	5,370	8	12	9	14	11	16	12	18	14	21	0	0	0	0
0407 Eastern Lake Erie	34	5,714	4,744	12	14	12	14	12	15	12	15	13	16	0	0	0	0
0502 Upper Ohio - Big Sandy	55	64,365	52,765	1	1	1	1	1	2	1	2	2	3	0	0	0	0
0503 Muskingum - Scioto - MI	24	12,762	9,702	2	3	2	3	3	4	4	5	5	6	0	0	0	0
0506 Wabash	15	19,965	13,465	1	2	1	2	2	2	2	3	3	5	0	0	0	0
0701 Mississippi Hdwaters	29	10,506	6,606	2	3	2	3	3	4	4	5	4	6	0	0	0	0
0702 Bk - Root - Chippewa - WI	43	27,079	21,279	1	1	1	1	1	1	1	1	1	2	0	0	0	0
0703 Rock - Miss - Des Moines	8	43,589	31,589	1	1	1	1	1	1	1	2	2	3	0	0	0	0
0704 Salt - SNY - Illinois	10	63,254	48,054	0	1	0	1	1	1	1	1	1	2	0	0	0	0
0705 Low/Up Mississippi	31	121,217	92,017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0901 Souris - Red - Rainy	26	6,122	3,472	2	3	2	4	3	6	5	8	7	13	0	0	0	0
1009 Middle Missouri	7	24,956	21,256	1	1	1	1	1	1	1	1	1	1	0	0	0	0
1011 Lower Missouri	29	44,286	30,086	0	1	0	1	1	1	1	1	1	1	0	0	0	0

Annual total		495,263	375,523	1	1	1	1	1	2	1	2	2	3				
Southeast																	
0205 Up/Low Chesapeake	51	14,812	11,312	0	2	1	3	3	4	3	5	4	6	0	0	0	0
0301 Roanoke - Cape Fear	69	26,210	19,110	1	2	1	2	2	3	3	4	4	5	0	0	0	0
0302 Pee Dee - Edisto	61	28,286	19,886	1	1	1	2	2	3	3	4	4	6	0	0	0	0
0303 Savannah - St. Mary's	67	25,605	17,605	1	1	1	1	2	2	2	3	3	4	0	0	0	0
0304 St. John's - Suwanee	68	19,614	11,514	6	10	6	11	7	13	8	14	9	16	0	0	0	0
0305 Southern Florida	48	9,434	6,264	23	35	25	37	27	41	29	44	33	50	0	0	0	0
0306 Apalachicola	65	22,004	16,804	1	1	1	1	2	2	2	3	3	4	0	0	0	0
Annual total		145,965	102,495	3	4	3	5	4	6	5	7	6	9				
South Central																	
0307 Ala - Choctawhatchee	68	40,258	31,858	0	1	0	1	1	1	2	2	2	3	0	0	0	0
0308 Mobile - Tombigbee	68	41,990	32,290	0	1	0	1	1	1	1	1	1	1	0	0	0	0
0309 Pascagoula - Pearl	68	19,137	13,337	1	1	1	1	1	1	1	1	1	2	0	0	0	0
0505 KY - Licking - Gr - Ohio	45	178,250	141,250	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0507 Cumberland	51	21,665	16,465	0	0	0	0	1	1	1	1	1	2	0	0	0	0
0601 Upper Tennessee	57	23,316	19,516	1	1	1	1	2	2	2	2	3	3	0	0	0	0
0602 Lower Tennessee	49	40,897	35,997	0	0	0	0	1	1	1	1	1	1	0	0	0	0
0801 Hatchie - Miss - St. Fran	27	346,271	226,271	0	1	0	1	0	1	0	1	1	1	0	0	0	0
0802 Yazoo - Miss - Quichita	58	387,656	254,656	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0803 Mississippi Delta	46	434,688	283,688	0	1	0	1	0	1	0	1	1	1	0	0	0	0
1101 Upper White	71	15,994	10,594	1	1	1	1	1	1	1	1	1	1	0	0	0	0
1104 Lower Arkansas	55	27,293	15,198	1	2	1	2	2	3	2	3	2	4	0	0	2	3
1105 Canadian	68	3,911	1,991	62	123	62	121	61	119	61	120	62	121	0	0	0	10
1106 Red - Washita	56	3,337	2,537	68	90	70	92	73	96	71	94	68	89	0	0	0	6
1107 Red - Sulphur	59	19,877	12,177	1	1	1	1	1	2	1	2	1	2	0	0	0	0
1201 Sabine - Neches	62	10,763	5,613	5	9	5	9	5	10	7	13	10	18	0	0	0	2
1202 Trinity - Galveston By	41	8,804	4,474	18	36	19	38	21	42	25	48	31	60	0	0	0	0
1203 Brazos	47	5,803	2,703	84	179	75	160	66	142	62	133	53	114	1	3	3	8
1204 Colorado (Texas)	70	3,714	2,550	82	120	77	112	72	104	70	102	67	98	1	4	4	6
1205 Nuecas - Texas Coastal	72	4,867	2,607	26	48	26	49	27	51	27	50	26	48	0	0	0	0
1303 Rio Grande - Pecos	93	922	631	68	100	68	100	68	99	60	88	45	66	0	1	0	6
1305 Lower Rio Grande	83	2,437	1,477	50	83	51	84	52	86	50	83	48	78	0	0	5	5
Annual total		1,641,850	1,117,875	1	2	1	2	1	2	1	2	2	2				
Rocky Mountains																	
1001 MO - Milk - Saskatchewan	46	6,227	4,967	5	6	7	8	9	11	9	11	9	11	0	0	0	0
1002 Missouri - Marias	68	6,085	5,005	22	26	30	36	39	47	39	47	39	47	0	0	0	0
1003 Missouri - Musselshell	71	5,679	4,519	3	3	4	4	5	6	5	6	5	6	0	0	0	0
1004 Yellowstone	64	9,839	8,159	21	26	26	32	32	39	32	39	31	38	0	0	0	0
1007 No/So Platte	61	3,899	3,616	85	92	84	90	82	88	85	91	91	98	2	4	4	4
1102 Upper Arkansas	65	877	813	85	91	83	89	81	87	79	84	72	78	1	2	5	5
1301 Rio Grande Hdwaters	71	848	687	69	85	76	93	83	102	82	101	81	100	0	2	0	4
1302 Middle Rio Grande	67	1,325	1,169	94	107	97	110	101	114	101	114	100	113	0	5	4	10
1304 Upper Pecos	74	595	510	94	110	81	89	67	78	69	80	73	85	3	4	7	7
1401 Green - White - Yampa	46	4,699	3,699	22	28	23	29	25	31	25	32	26	33	0	0	1	1
1402 Colorado - Gunnison	46	5,727	4,407	17	22	17	22	18	23	18	24	19	25	0	0	0	0
1403 Colorado - San Juan	48	10,434	7,454	4	6	6	8	8	11	8	12	9	13	0	0	0	0
1501 Little Colorado	86	340	268	21	27	27	30	34	43	36	46	40	51	0	0	0	0

Table 7.11—*Fresh water supply, percentage depletion (current and projected) in average and dry year, and number of months consumptive use exceeds 90 percent depletion in average and dry years in the United States, by region and subregion — continued*

Resource Planning Act region and water resource subregion	Percent of area in forest and range	Water supply: Mean[1]	Water supply: Dry[2]	Percentage depletion[3] 1975 Mean	1975 Dry	1980 Mean	1980 Dry	1985 Mean	1985 Dry	1990 Mean	1990 Dry	2000 Mean	2000 Dry	Number of months that 1975 consumptive use would exceed 90% supply: With ground water[4] mining Mean	With ground water[4] mining Dry	Without ground water[4] mining Mean	Without ground water[4] mining Dry
		Million gallons per day		*Percent*		*Percent*		*Percent*		*Percent*		*Percent*		*Number*		*Number*	
Rocky Mountains (continued)																	
1502 Lower Colo - Main Stem	31	2,319	2,129	46	50	46	50	47	51	48	52	49	53	0	0	0	0
1503 Gila	71	1,363	1,344	254	258	257	261	260	264	258	261	253	256	12	12	12	12
1601 Bear - Great Salt Lake	48	2,852	2,452	44	51	43	49	41	47	42	48	44	51	3	3	8	8
1602 Sevier Lake	39	473	449	127	133	121	127	115	121	116	122	117	123	4	5	4	5
1603 Humboldt - Tonopah Des	22	923	848	117	127	125	135	133	144	137	148	144	156	4	5	5	6
1604 Central Lahontan	15	1,502	1,085	56	78	56	78	56	77	57	79	60	84	4	4	5	5
1701 Clark Fork - Kootenai	86	32,016	27,316	2	2	2	2	3	3	3	3	3	4	0	0	0	0
1703 Upper/Central Snake	43	15,503	13,033	33	39	35	42	38	45	38	45	37	44	0	0	0	0
1704 Lower Snake	77	30,109	24,809	1	2	1	2	2	2	2	2	2	3	0	0	0	0
Annual total		143,634	118,738	19	23	20	25	22	27	22	27	22	27				
Great Plains																	
1005 Western Dakotas	59	14,702	11,102	3	5	3	5	4	5	4	6	5	7	0	0	0	0
1006 Eastern Dakotas	18	16,667	13,167	1	1	1	2	2	3	3	4	4	5	0	0	0	0
1008 Niobrara - Platte - Loup	63	6,816	6,046	49	55	55	62	61	69	60	68	59	67	0	1	0	3
1010 Kansas	36	6,176	4,166	63	93	64	95	66	97	65	96	64	95	0	2	1	3
1103 Arkansas - Cimarron	33	4,213	1,793	48	113	54	126	60	140	160	141	61	142	0	2	1	4
Annual total		48,574	36,274	20	27	22	29	24	32	24	32	25	33				
Pacific Northwest																	
1702 Upper/Mid Columbia	67	118,691	102,491	3	4	3	4	4	5	4	5	4	5	0	0	0	0
1705 Coast - Lower Columbia	75	212,740	177,740	0	0	0	0	1	1	1	1	1	1	0	0	0	0
1706 Puget Sound	68	42,394	36,094	0	1	0	1	1	1	1	1	1	1	0	0	0	0
1707 Oregon Closed Basin	36	1,803	1,166	41	64	48	76	56	87	55	86	53	83	0	0	3	3
Annual total		375,636	317,491	2	2	2	2	2	2	2	2	2	2				
Pacific Southwest																	
1801 Klamath - N. Coastal	80	26,737	18,537	3	4	3	4	4	5	4	5	4	5	0	0	0	0
1802 Sacramento - Lahontan	74	19,065	14,105	28	38	29	40	31	42	32	43	33	44	0	0	0	0
1803 San Joaquin - Tulare	53	14,229	12,599	89	100	91	103	94	107	97	110	103	116	3	4	6	7
1804 San Francisco Bay	57	3,379	2,049	24	39	26	43	29	48	30	50	33	55	2	2	0	3
1805 Central Cal. Coast	68	2,240	1,157	37	72	40	79	44	86	45	89	48	94	2	4	5	7
1806 Southern California	23	5,842	5,487	101	107	96	102	91	97	91	97	90	96	7	8	12	12

Pacific Southwest (continued) 1807 Lahontan - South	34	327	277	100	118	99	117	98	116	100	118	104	122	5	6	6	6
Annual total		71,819	54,211	37	49	38	50	39	52	40	53	41	55				
1901 Alaska annual total	33	905,058	795,058	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hawaii																	
2001 Hawaii County	43	3,521	2,811	1	1	1	1	1	1	1	1	1	2	0	0	0	0
2002 Maui County	59	1,482	963	17	26	17	27	18	28	18	28	19	29	0	0	0	0
2003 Honolulu County	67	562	414	28	37	29	38	30	40	31	42	33	45	0	0	0	0
2004 Kaui County	64	1,787	1,327	9	13	9	13	9	12	9	12	9	12	0	0	0	0
Annual total		7,352	5,515	8	11	8	11	9	12	9	12	9	12				
Caribbean																	
2101 Puerto Rico	21	5,177	3,627	7	9	7	8	7	10	7	9	6	8	0	0	0	0
2102 Virgin Islands	25	4	3	75	100	113	133	125	167	150	200	200	267	0	6	0	12
Annual total		5,181	3,630	7	9	7	9	7	10	7	9	6	8				

[1] Water supply that can be expected on the average.
[2] Water that can be expected 90 percent of the time.
[3] Proportion of water supply that is used consumptively.
[4] Ground water mining - extraction of ground water at a rate faster than it is being replenished.

Source: See source note table 7.1.

Water Quality

The natural quality of water in the Nation's streams and lakes is, in large part, a reflection of the characteristics of the land and vegetation from which the water flows. Because of the natural variation in land and vegetation, the natural quality of water in streams and lakes is neither uniform nor static. Water is constantly moving, even in lakes and reservoirs; as it moves, its quality changes. It is influenced by natural features including geological features, soil, vegetation, natural landslides, and wildfire.

The natural quality of water is also affected by the actions of people. These actions include road construction, urban development, farming, mining, timber harvesting, livestock grazing, and dumping of municipal and industrial wastes. Acid precipitation, which occurs when precipitation falls through air containing heavy concentrations of sulfur, also affects water quality, especially near heavily industrialized areas.

Water is often used and reused several times and for many purposes during its journey to the sea. Quality can be either improved or degraded as it is used and returned to the stream. Because it is ever-moving and ever-changing, water quality and quantity are difficult to inventory or measure.

It is important to realize that water quality determines the usability of water and that quality can be good or bad, depending on the specific uses man wishes to make of it. For example, a clear alpine lake may be excellent for esthetic enjoyment and trout fishing, but very poor for swimming since the water temperature rarely exceeds 10 degrees centigrade. Another example would be when the natural water quality is ideal for swimming and for fish, wildlife, and livestock, but is unsatisfactory for industrial use because of the content of total dissolved solids.

To show the relationship of water quality to its natural environment, relatively undisturbed forest and range land watersheds with available water quality data were selected in each division, province, or section as described by Bailey.[7,8] Bailey's hierarchical system for land classification (ecoregions) begins with the largest, broadest definition as a domain, and proceeds downward in size and in specificity through division and province to section, the smallest and most discrete unit. Each section describes a more or less continuous geographical area and is characterized by distinctive fauna, climate, landform (including drainage pattern), soil, and vegetation that distin-

[7] Bailey, Robert. Ecoregions of the United States (map). U.S. Department of Agriculture, Forest Service, Ogden, Utah. 1976.

[8] Bailey, Robert. Description of the ecoregions of the United States. U.S. Department of Agriculture, Forest Service, Ogden, Utah.

guishes it from adjacent sections. Within such sections, ecological relationships between plants, soil, and climate are essentially similar, so similar management treatments give comparable results and have similar effects on the environment. They are considered to be biological and physical areas of a specific potential.

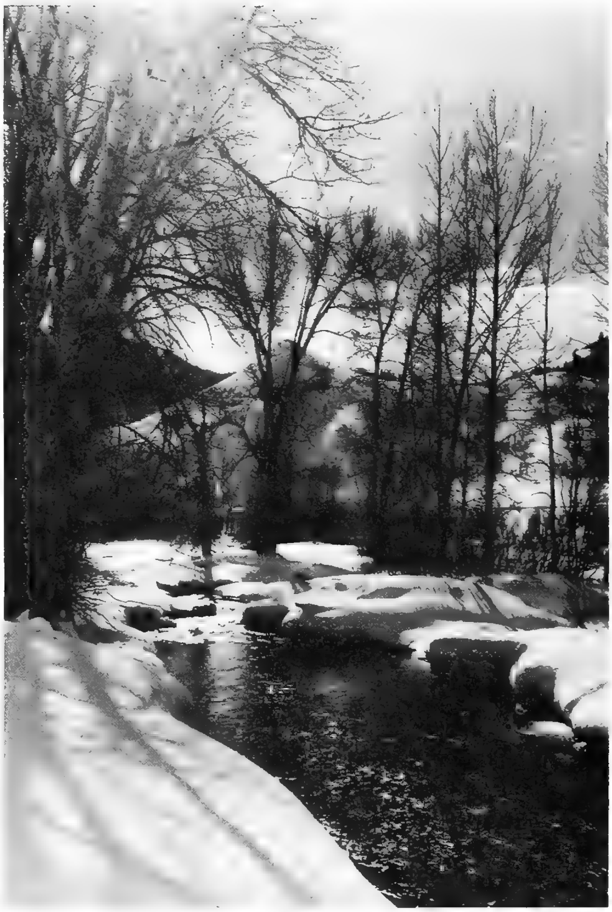
In addition to being relatively undisturbed (no major land disturbing activities within at least the last 5 years), the selected watersheds were also small (10 to 200 square miles), more than 90 percent forest or range land or both, and had a minimum of 5 years (10 years when possible) of water quality records that included total dissolved solids, water temperature, suspended sediment, and dissolved oxygen. These data, primarily from STORET,[9] are presented in table 7.12 to show water quality for these parameters by ecoregion.

The quality of the water in all of the undisturbed watersheds exceeds the minimum water quality standards of most States. There is, however, a substantial amount of variability in the various measures of quality among the divisions, provinces, and sections.

Controlling water pollution and improving the quality of the Nation's waters are important public policy objectives. The Federal Water Pollution Act Amendments of 1972 (Public Law 92-500) established a goal of eliminating by 1985 the discharge of pollutants into the Nation's navigable waters; an interim goal was to provide by July 1, 1983, wherever attainable, water quality sufficient for recreation and the protection and propagation of fish, shellfish, and wildlife. The Administrator of the Environmental Protection Agency is charged with directing efforts to achieve these goals.

The Federal Water Pollution Control Act Amendments of 1972 defined two broad sources of pollution — point source and nonpoint source. Point sources are those that generally originate at a known location, are transported through pipes, and are discharged into receiving waters at a fixed point. Nonpoint sources, on the other hand, are diffuse in origin, their transportation into receiving water is not well defined or constant, their discharge occurs at many diffuse locations, and depends heavily on weather conditions such as rainstorms or snowmelt.

The initial thrust of the pollution control efforts to reach the goals set forth in the Federal Water Pollution Control Act Amendments was related to point sources. Those programs were so successful in controlling point source pollution that both the Environmental Protection Agency[10] and the Comptroller General[11] identified nonpoint source pollution as the limiting factor in reaching the stated goals in many of the 246 hydrological drainage basins across the Nation identified by the Environmental Protection Agency.[12]



Water quality is in large part a reflection of the land and vegetation from which the water flows.

[9] STORET, an acronym for the Environmental Protection Agency's quality data storage and retrieval program.

[10] U.S. Environmental Protection Agency. National water quality inventory, 1977, report to Congress. Unpublished draft.

[11] The Comptroller General of the United States. Report to the Congress. National water quality goals cannot be attained without more attention to pollution from diffused or "nonpoint" sources, December 20, 1977.

[12] U.S. Environmental Protection Agency. STORET user handbook. Office of water and hazardous materials, Washington, D.C., June 1977; and associated map EPA-STORET major/minor river basins, March 1973.

Table 7.12 — *Data for selected measures of water quality from undisturbed forest and range watersheds in the United States, by division, province, and section*

Division, province, and section	Measures of quality											
	Total dissolved solids (mg/1)[1]			Dissolved oxygen (% saturation)[2]			Water temperature (degrees centigrade)			Suspended sediment (mg/1)[3]		
	Percentile[4]			Percentile			Percentile			Percentile		
	15	50	85	15	50	85	15	50	85	15	50	85
1300 Subarctic												
M1310 Alaska Range	50	90	120	90	95	100	0	6.0	13.0	1	3	40
											(100)	(500)[5]
1320 Yukon Forest	43	63	80	95	98	100	0	3.8	7.5	10	20	40[6]
2100 Warm Continental												
2110 Laurentian Mixed Forest												
2111 Spruce-fir	62	91	120	79	90	104	0	10.0	15.5	0	4	14
2112 Northern Hardwoods-Fir	68	104	132	77	87	98	0	8.0	20.0	2	4	10
2113 Northern Hardwoods	25	29	35	89	97	105	0	8.0	17.0	1	3	8
2114 Northern Hardwoods-Spruce	16	20	25	86	92	100	0	4.0	19.0	1	2	5
M2110 Columbia Forest												
M2111 Douglas-fir Forest	70	100	150	85	91	97	3.0	4.0	9.0	10	40	60
M2112 Cedar-Hemlock-Douglas-fir	48	52	54	85	95	105	0	6.0	11.0	2	5	10
2200 Hot Continental												
2210 Eastern Deciduous Forest												
2211 Mixed Mesophytic	14	16	18	87	93	100	4.5	10.0	16.0	2	4	17
2212 Beech-Maple	206	368	556	80	94	100	4.0	10.5	23.0	2	24	95
2213 Maple-Basswood + Oak Savanna	239	294	313	86	96	110	1.0	9.0	17.0	14	48	734
2214 Appalachia Oak	22	25	29	89	97	105	2.0	6.0	15.0			
2215 Oak Hickory	44	62	156	84	94	105	7.0	15.0	23.0	2	8	40
2300 Subtropical												
2310 Outer Coastal Plain Forest												
2311 Beech-Sweetgum-Magnolia-Pine-Oak	16	23	53	73	83	90	10.0	18.0	24.0	4	19	
2312 Southern Flood Plain	16	23	53	73	83	90	10.0	18.0	24.0	4	19	93
2320 Southeastern Mixed Forest	15	22	34	91	98	105	9.0	16.0	23.0	3	7	20
2400 Marine												
2410 Willamette-Puget Forest	46	62	75	70	80	90	2.0	12.0	18.0	5	10	20
M2410 Pacific Forest	15	40	75	95	98	100	1.0	5.0	9.0	1	3	40
										(20)	(80)	(400)[5]
M2411 Sitka-Spruce-Cedar-Hemlock	34	48	65	92	95	98	4.0	8.0	11.0	1	2	8
M2412 Redwood Forest	52	87	124	95	98	105	7.0	12.1	18.0	3	26	118
M2413 Cedar-Hemlock-Douglas-fir	25	50	90	85	90	95	3.0	9.0	16.0	4	8	12
M2414 California Mixed Evergreen	50	120	150	93	97	99	8.0	14.5	21.2	6	45	175
M2415 Silver Fir-Douglas-fir	23	46	68	85	90	94	1.4	6.2	10.9	2	5	10
2500 Prairie												
2510 Prairie Parkland												
2511 Oak-Hickory-Bluestem	235	314	370	76	94	128	0	13.0	22.0	17	55	214
2512 Oak + Bluestem	51	55	58	—	—	—	11.0	20.0	25.0	—	—	—
2520 Prairie Brushland												
2521 Mesquite-Buffalo Grass	240	270	280	83	94	100	12.0	19.0	26.0	2	8	80
2522 Juniper-Oak-Mesquite	244	278	290	83	94	100	11.5	19.0	25.5	2	8	80
2523 Mesquite-Acacia	250	280	295	82	92	100	12.0	19.0	26.0	2	8	80
2530 Tall-grass Prairie												
2531 Bluestem	352	868	1060	70	86	100	0	9.0	19.5	24	80	199
2532 Wheatgrass-Bluestem-Needlegrass	149	155	161	78	83	90	4.5	9.5	20.0	448	508	650
2533 Bluestem-Grama	72	104	133	54	81	100	5.0	13.0	23.0	—	—	—

See footnotes at end of table.

Table 7.12 — *Data for selected measures of water quality from undisturbed forest and range watersheds in the United States, by division, province, and section — continued*

Division, province, and section	Total dissolved solids (mg/1)[1]			Dissolved oxygen (% saturation)[2]			Water temperature (degrees centigrade)			Suspended sediment (mg/1)[3]		
	Percentile[4]			Percentile			Percentile			Percentile		
	15	50	85	15	50	85	15	50	85	15	50	85
2600 Mediterranean												
2610 California Grassland	400	600	800	90	95	100	8.0	18.0	28.0	30	60	90
M2610 Sierran Forest	11	19	20	90	96	102	6.2	13.8	15.5	1	3	5
M2620 California Chaparral	300	600	800	90	94	98	7.2	17.8	24.1	10	20	30
3100 Steepe												
3110 Great Plains Shortgrass Prairie												
3111 Grama-Needlegrass-Wheatgrass	994	2189	3384	53	70	87	1.4	9.7	18.0	10	6000	16186
3112 Wheatgrass-Needlegrass[7]	235	257	269	70	80	87	0	4.0	12.0	25	47	81
3113 Grama-Buffalo Grass	1491	1610	1730	80	92	104	4.0	13.0	21.0	118	188	258
M3110 Rocky Mountain Forest												
M3111 Grand Fir-Douglas-fir	32	48	57	87	94	99	1.5	8.0	15.5	1	6	22
M3112 Douglas-fir	25	140	400	76	83	110	0	6.0	12.0	7	25	300
M3113 Ponderosa Pine-Douglas-fir	38	52	60	65	73	78	0	4.0	11.0	2	4	9
3120 Palouse Grassland	200	250	300	60	70	80	2.0	10.0	17.0	50	500	5000
M3120 Upper Gila Mountains Forest	63	128	173	73	87	114	6.0	11.0	21.0	1	2	20
3130 Intermountain Sagebrush												
3131 Sagebrush-Wheatgrass	85	109	124	9	11	12	2.0	11.0	24.0	4	9	57
3132 Lahontan Saltbush-Greasewood	50	80	100	74	79	84	1.0	8.0	15.0	13	30	177
3133 Great Basin Sagebrush	70	80	100	73	80	90	1.0	8.0	15.0	2	25	1970
3134 Bonneville Saltbush-Greasewood	1000	1400	3200	70	80	90	2.0	9.0	15.0	10	30	2000
3135 Ponderosa Shrub Forest	55	59	66	75	85	95	1.0	14.0	19.0	5.6	17.5	59.5
P 3130 Colorado Plateau												
P 3131 Juniper-Pinyon Woodland+ Sagebrush-Saltbush Mosaic	150	225	350	70	85	100	4.0	13.0	21.0	5	25	500
P 3132 Grama-Galleta Steepe + Juniper-Pinyon Woodland	158	228	390	85	95	145	5.0	16.0	23.0	19800	24800	37900
3140 Mexican Highlands Shrub	427	915	1180	95	105	105	15.0	25.0	33.0	14200	68940	111000
A 3140 Wyoming Basin												
A 3141 Wheatgrass-Needlegrass-Sage	220	495	770	78	87	96	2.0	9.0	17.0	78	850	1622
A 3142 Sagebrush-Wheatgrass	190	267	344	71	82	93	2.0	9.0	17.0	1	191	565
3200 Desert												
3210 Chihuahuan Desert												
3211 Grama-Tobosa	1900	2450	2990	100	120	130	8.0	18.0	27.0	12	55	86
3212 Tarbush-Creosote Bush	93	114	132	—	—	—	13.0	21.0	25.0	—	—	—
3220 American (Mojave-Colorado-Sonoran)												
3221 Creosote Bush	509	541	603	70	105	140	13.0	21.0	28.0	7	576	1030
3222 Creosote Bush-Bur Sage	600	700	800	60	70	100	13.0	26.0	32.0	1000	5000	20000
4200 Rainforest												
M4210 Hawaiian Islands	22	33	51	89	94	100	17.0	19.0	20.0	0	1	3

[1] All solid material that passes through a filter membrane having pores of 0.45 micron in diameter. Measured in milligrams per liter (mg/1).

[2] The ratio of the amount of dissolved oxygen present in water at a given temperature to the amount of dissolved oxygen water can hold at that temperature, expressed as a percent.

[3] The inorganic particles larger than 0.45 micron in diameter carried in suspension by the water. Measured in milligrams per liter (mg/1).

[4] Percentile figures are determined from an analysis of a frequency distribution. The 50th percentile represents the median (midpoint) of the data and a range is selected in which 70 percent of the data falls between the 15th and 85th percentiles.

[5] Figures in ( ) are for streams with a major contribution from glacial melt and are for the same ecoregions as figures immediately preceeding.

[6] Suspended sediment figures for Yukon Forest do not include that measured in the Yukon River which is a glacial melt river originating in Canada.

[7] These figures represent only the Black Hills portion of this ecoregion.

Note: Numbers before the division, province, and section designations refer to lowland ecoregions as described in Forest Service, U.S. Department of Agriculture, *Ecoregions of the United States,* 1976. Letters with the numbers, i.e., M1310, P3131, A3142, etc., indicate highland ecoregions in which M = mountains, P = plateau, and A = altiplano (a high plateau or plain).

Source: U.S. Environmental Protection Agency. National Water Quality Data Storage and Retrieval Program (STORET).

Point Source Pollution — Problem Areas

Point source pollution is generated primarily by industries and municipalities and is generally incidental to forest and range lands. However, several kinds of operations associated with forest and range lands do generate point source pollution. Some of these are relatively permanent and generate pollution on a year-round basis, but others are only temporary or seasonal. Common sources of potential point source pollution on forest and range lands include: rock crushing and gravel washing; log sorting and storage; wood processing; mining; food processing; developed recreation sites; feedlots; marine vessels; remote work centers (logging and mining camps); summer homes; and organization camps. These sources of point pollution are found, collectively, in nearly every hydrologic basin identified by the Environmental Protection Agency,[13] though not all are considered pollution problems in all basins. In fact, pollution from these sources is generally not significant on a national basis, but it can be significant locally if not controlled. A summary of the major point pollution sources and the related types of pollution is shown in table 7.13 by each major region as defined by the Environmental Protection Agency.

Nonpoint Source Pollution — Problem Areas

Most pollution from activities on forest and range land is nonpoint source. As mentioned earlier, nonpoint sources of pollution are becoming, or have already become, the primary source of pollution in many streams. There are several recognized categories of nonpoint source pollution including mining; urban runoff; construction of roads and buildings; silviculture — man's activities in growing and harvesting timber; agriculture; hydrologic modification of surface or ground waters; subsurface excavations — industrial injection wells, septic tanks and landfills; and saltwater intrusion into fresh water supplies. Of these, mining, silviculture, construction, and the grazing aspects of agriculture are commonly recognized as causing significant nonpoint source pollution from forest and range lands. The other categories of nonpoint source pollution do cause significant pollution from forest, range, and associated lands in local areas, but on a nationwide basis they are not considered a major problem.

One of the greatest problems associated with nonpoint source polution is that it is often difficult to identify, measure, or treat because it is diffuse and diluted. However, while impacts of nonpoint source pollution are often less concentrated and conspicuous, they are not necessarily less harmful than the impacts of point source pollution. To the extent that forests and range lands and their uses contribute to nonpoint source pollution, this will generally occur in those stream reaches and lakes where the water is of relatively high quality. Any degradation of quality in these areas is easily noticed and difficult to treat.

Another serious problem of nonpoint source pollution is separating pollution induced by man from that which occurs naturally. Most wildlands, even under natural conditions, are sources of many pollutants which contribute to the total load of nonpoint source pollution. These natural pollutants are in the form of sediment, but organic and chemical pollution also occur from natural sources.

A third major problem related to nonpoint source pollution is the lack of data on the sources, extent, and impacts of nonpoint pollution on water quality.

Just as there are general nonpoint source pollution problems, so are there specific problem areas. The agricultural industry is probably the largest single contributor to nonpoint source pollution. By volume, the major pollutant is sediment, primarily from soil erosion of croplands and stream channels. Cropland contributes about 40 percent or more of the total sediment deposited in streams and lakes. About 19 percent is from forest and range lands and 30 percent is from roadsides, streambanks, and mining. Urban and other sources contribute the remaining 11 percent.[14]

Water quality is affected by nonpoint source pollution from mining in two ways — acid-mine drainage and sediment, both of which are more common from abandoned mines. Acid drainage occurs when exposed sulphur-bearing rock reacts with air and water to form sulfuric acid. This acid then leaches through the ground, including tailings, where it dissolves other minerals and metals, and continues its journey until it reaches a stream or lake. Acid drainage affects pH (the measure of hydrogen-ion activity of solutions), dissolved solids content, and toxic aspects of water quality. Sediment is produced by runoff from any unprotected soil, whether it be from roads, areas cleared of vegetation for mining, or tailings. Pollution from mining can be a special problem to communities, both human and natural biota, located near the source of the drainage.

Silviculture is the primary source of nonpoint pollution most commonly associated with forest lands. Many activities inherent in forest management are included in the term "silviculture," including nursery

[13] U.S. Environmental Protection Agency. National water quality inventory, 1977 report to Congress, *op. cit.*

[14] U.S. Department of Agriculture, Soil Conservation Service. Environmental impact statement, rural clean water program, August 24, 1978.

Table 7.13 — *Percentage of hydrologic basins affected[1] by point sources of pollution in the United States, by region,[2] source, and type of pollution*

Region	Number of hydrologic basins	Percentage of basins affected												
		Source of pollution			Type of pollution									
		Industrial	Municipal	Combined sewer overflow	Thermal	Bacteria	Oxygen depletion	Nutrients	Sus-pended solids	Dissolved solids	pH	Oil and grease	Heavy metals	Non-metal toxics
Northeast	40	95	95	60	33	93	93	78	70	13	15	35	58	43
Southeast	47	74	91	17	11	77	89	70	26	9	17	6	26	28
Great Lakes	41	80	95	37	24	80	85	71	44	27	24	34	51	59
North Central	35	74	86	6	11	89	80	74	23	20	14	0	57	23
South Central	30	70	100	0	3	73	87	83	30	30	10	13	43	7
Southwest	22	23	64	0	5	50	36	41	14	23	5	5	9	5
Northwest	22	55	73	14	0	68	55	55	23	5	5	0	5	14
Islands	9	89	100	0	33	89	78	56	33	11	0	44	22	11
Total	246	72	89	21	15	78	79	69	35	17	14	16	38	28

[1] Percentage is based on the number of basins affected, either wholly or in part. As little as 5 percent or as much as 100 percent of an individual basin could be affected and the basin would be included.

[2] Region is the grouping of hydrological basins as defined by the Environmental Protection Agency.

Source: U.S. Environmental Protection Agency. *National water quality inventory*, 1977 report to Congress. Unpublished draft.

Table 7.14 — *Percentage of hydrologic basins affected[1] by nonpoint sources of pollution in the United States, by region,[2] source, and type of pollution*

Region	Number of hydro-logic basins	Percentage of basins affected															
		Source of pollution								Type of pollution							
		Urban runoff	Con-struc-tion	Hydro-logic modifi-cation	Silvi-cul-ture	Mining	Agri-cul-ture	Solid waste dis-posal	Indi-vidual dis-posal	Bac-teria	Oxy-gen deple-tion	Nutri-ents	Sus-pended solids	Dis-solved solids	pH	Oil and grease	Toxics	Pesti-cides
Northeast	40	70	15	20	10	20	55	35	63	70	53	63	65	10	18	15	33	18
Southeast	47	57	2	21	30	15	62	9	40	66	74	57	34	4	9	4	11	23
Great Lakes	41	54	7	2	15	41	59	15	39	51	54	44	56	27	37	20	34	15
North Central	35	54	6	3	6	40	89	9	29	69	66	63	80	51	20	0	51	37
South Central	30	50	0	23	13	53	87	13	40	53	43	63	37	70	23	3	47	40
Southwest	22	23	0	18	5	36	79	0	35	36	14	45	32	68	14	14	27	0
Northwest	22	23	23	23	27	23	55	9	32	64	18	55	64	14	9	5	32	0
Islands	9	67	67	22	0	0	78	22	89	89	44	44	100	0	0	0	22	44
Total	246	62	9	15	15	30	68	14	43	61	51	56	54	30	18	9	32	22

[1] Percentage is based on the number of basins affected, either wholly or in part. As little as 5 percent or as much as 100 percent of an individual basin could be affected and the basin would be included.

[2] Region is the grouping of hydrological basins as defined by the Environmental Protection Agency.

Source: See source note table 13.

operations, site preparation, reforestation, and subsequent culture operations, such as thinning, prescribed burning, pest and fire control, timber harvesting, and the construction and maintenance of roads and other transportation systems associated with these activities. Forests are generally free of accelerated erosion unless they have been disturbed by fire, grazing, timber harvesting, mining, or construction.

Typical pollutants caused by silvicultural activities include sediment, nutrient, pesticide, thermal, and organic material (which causes oxygen depletion). Sediment is caused primarily by road construction, but other types of construction, such as that of power and pipe lines or dams, also contribute to sediment loads on a local basis. Timber harvesting, aside from the associated roads and skid trails, usually does not produce much sediment. The greatest impact of erosion from forest and range lands is not always that of water pollution. In some instances, especially where there is severe sheet erosion or where mass failures occur, the loss of soil productivity is of greater consequence. The available data indicate that the percentage of forest and range lands on which this type of erosion occurs is minimal.

Nutrient enrichment of streams is a natural process that is fairly constant from all forest and range lands. Decomposition of vegetation is the greatest natural source of nutrients, but livestock and wildlife manure also add to the total load. Some nutrients are deposited directly into streams and lakes in the form of organic matter as a result of needle cast, leaf fall, and the activities of wildlife such as beaver and muskrats. The decomposition of organic matter within the aquatic ecosystem results in oxygen depletion, which, under certain flow conditions, can cause critical water quality degradation. Both the nutrient and organic matter content of streams and lakes can be increased temporarily by management activities. Fertilization of forests and range lands to increased growth can cause a temporary increase in nutrients immediately after application, especially after the first rainfall. Timber harvesting, especially clearcutting, also can cause a temporary increase in both nutrients and organic matter. Figure 7.11 illustrates the relation between selected land uses and nutrient concentration (total phosphorus and nitrogen) in streams.

Pesticides could become a major source of nonpoint pollution from forests and range lands. Incidents over the past several years have shown that indiscriminate use of pesticides, either in the type, quantity used, or method or timing of application can lead to severe water quality problems. The use of pesticides on forest and range lands is primarily for control of undesirable insects and vegetation. Research has shown that pesticides applied in the proper amount, at the proper time, and by the proper method are effective in controlling undesirable insects or vegetation, and cause little pollution.[15] Most pollution that does occur results from direct application (drift) to bodies of water or from heavy rainfall within a short time of application. In either situation, the source for pollution exists for only a short period, and the pollutant is immediately diluted when it mixes with uncontaminated water.

Thermal pollution, the warming of stream or lake waters above a given temperature, also can occur from land management activities. Water temperature is affected by direct exposure to the sun's energy through absorption by the materials that make up the streambed. Any activity that opens up more of a stream or lake to the direct radiation of the sun can have an adverse effect on water temperature. This could be caused by road or other construction, timber-harvesting operations, overgrazing by livestock or wildlife, or fire. Even when temperatures are raised as a result of these activities, there is some question of whether warming of streams should be considered as pollution in all situations. Warming also can occur as a result of sedimentation (shallow water warms more easily than deep water) or increased concentration of suspended matter, either organic or inorganic. Although there is some warming as a result of absorption by the suspended particles, the greater effect of pollution is generally that caused by the sediment or decomposition of the organic matter.

Many other activities that take place on forest, range, and associated lands also cause nonpoint source pollution. Some of these activities, and the kinds of pollution they cause, are: off-road vehicle use-sediment (grazing-sediment, bacteria, nutrients, and organic material); developed or concentrated recreation use-sediment (bacteria and pathogens); oil, gas, and mineral exploration-sediment (oil and chemicals). Pollution from these sources is not a problem on a national basis, but, again, it can be critical in local situations.

A study by the Environmental Protection Agency[16] identified agriculture, urban runoff, and individual waste disposal systems (septic tanks, etc.) as nonpoint

[15] U.S. Environmental Protection Agency. Silvicultural chemicals and protection of water quality. 1977.

[16] U.S. Environmental Protection Agency, national water quality inventory, now reflects "best management practices" as the best method of controlling nonpoint source pollution. The concept of best management practices is based on the premise that if land management activities are carried out under the best management practices known, the level of nonpoint pollution will be acceptable. Management decisions incorporating best management practices for grazing, silviculture, mining, and construction will determine to a large extent the success of the control and abatement of nonpoint source pollution from forest and range lands.

sources of pollution in 68, 62, and 43 percent, respectively, of the hydrologic basins inventoried throughout the Nation. The same study showed mining and silviculture as nonpoint sources in 30 and 15 percent of the basins, respectively. As one would expect, the proportion of the basins affected by the latter two activities is highest in those regions where mining and silviculture are most widespread. Again, it is important to note that only several of the individual basins listed as being affected by these activities are actually problem areas. And the severity of the problem within that basin, or even within that State, is generally minor in relation to other sources of nonpoint pollution. Pollution from these sources can be significant on a local basis, however. These and other nonpoint sources of pollution and types of pollution are summarized in table 7.14 in relation to the various regions of the Nation.

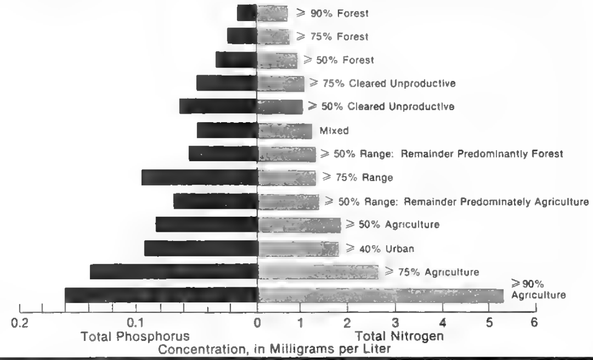
The most serious effects of nonpoint source pollution from forests and range lands are expected to be on recreational uses in remote areas where land management activities are currently taking place. Other serious effects can occasionally be expected in relation to fish spawning areas and in municipal watersheds for small towns where water treatment facilities are minimal. Impacts on health will generally be minor, but the use and enjoyment of water bodies within forests and range lands are likely to be reduced by nonpoint source pollution. If the effects of this pollution are severe enough, local recreation-based ventures could be affected economically.

The increased emphasis on controlling nonpoint source pollution has had a direct impact on management activities and uses of forest and range lands. Water quality objectives are being considered when making decisions about land use and management. Land and resource plans and implementation opportunities for all proposed projects must recognize potential nonpoint source pollution, and insure that all possible means are taken to prevent such pollution.

This increased emphasis also requires a new way of thinking about nonpoint source water quality standards and about how to meet them. Management activities now reflect "best management practices" as the best method of controlling nonpoint source pollution. The concept of best management practices is based on the premise that if land management activities are carried out under the best management practices known, the level of nonpoint pollution will be acceptable. Management decisions incorporating best management practices for grazing, silviculture, mining, and construction will determine to a large extent the success of the control and abatement of nonpoint source pollution from forest and range lands.

Figure 7.11

Relationships Between Land Use and Nutrient Concentrations in Streams



Sediment from soil erosion is a major pollutant in many streams and reservoirs.

Opportunities for Mitigating Water Problems

As indicated in preceding sections, water problems generally fall into three categories: inadequate supplies, flood damage, and low quality. Management of forests and rangelands presents opportunities for mitigating each of these problems. It is obvious that forest and range land management offers a solution to these problems only in conjunction with other approaches, but it can in some instances be a significant element in an overall approach that includes both structural and nonstructural problems and mechanisms.

Extending or Increasing Water Supplies

Of the 106 water resource subregions in the country as defined by the Water Resources Council (fig. 7.1), several are expected to experience severe water shortages, both currently and in future years. Figures 7.8 and 7.9 show the subregions by water depletion categories for mean and dry years. It is evident that, in the future, water must be used more efficiently or overall supplies must be increased in many subregions if the economic and social impacts from water shortages are to be avoided.

One thing is certain: there is no single solution. Across the Nation, there is remarkable diversity in the role that water plays. Over most of the West, water is scarce and must be managed carefully — and the detailed traditions and laws that have evolved dictate the use of water. In other areas, flooding is more of a problem than drought. There are many other examples.

The President's proposed water policy contains water conservation as its cornerstone. In many areas, usable supplies could be increased significantly through more efficient use of water. As indicated in the discussion of demand for water earlier in this chapter, the quantity of water demanded in the future for steam electric cooling and manufacturing is expected to decline substantially in some water resource regions because of environmental regulations that require cooling towers and recycling of processing water. These are examples of lowered demands for water that could be repeated for other uses and achieved in other ways.

Before discussing specific situations where water could be used more efficiently, the area of incentives for more efficient use will be discussed. Two broad types of incentives are possible to encourage water users to be more efficient: (1) economic, and (2) regulatory.

Probably the best way to implement incentives by economic means is through the price system. Currently, most water pricing systems are not based on incremental or marginal costs. Some suppliers charge a flat fee regardless of amounts used. Others offer quantity discounts. Prices for irrigation water are often set below the cost of amortizing and operating a delivery system. In the West, users of water are typically awarded a right to divert and use water free of charge, and they can disregard the value that some other use might yield. In many cases, there are no means for the sale of water rights to bring about a reallocation to higher value uses.[17]

[17] National Water Commission. Water policies for the future, final report to the President and Congress. U.S. Gov. Printing Office, Washington, D.C. 259 p. 1973.

Conservation is the cornerstone of meeting our future demands for water.

There is strong evidence that metering and pricing have substantial impacts on water use. For example, the introduction of metering reduced water use by 36 percent in Boulder, Colo.[18] The National Water Commission concluded that systems of pricing and user charges that recover the full cost of water services directly from users will conserve water supplies, discourage premature investment in water development projects, reduce financial burdens now borne by nonusers and, most importantly, make more efficient use of scarce resources.

The alternative to creating economic incentives is regulation. Much of the increased use of recycling techniques in manufacturing has resulted from requirements to meet environmental regulations.

If the user were responsible for conserving water through economic incentive or regulation, conservation would be likely in several areas. Making irrigation more efficient offers the best opportunities for significant water conservation. Considerable savings are possible in reducing losses from water transmission. Losses from both seepage and evapotranspiration are quite high in some areas. Possible solutions include lining channels and laterals, converting from surface flooding to trickle irrigation, using underground storage in years of high runoff, and phreatophyte management. The latter may have environmental effects that must be considered.

[18] Hanke, S. H. Demand for water under dynamic conditions. Water Resources Research, 6 (5):1253-61.

Domestic water use can be made more efficient by controlling leaks in transmission systems, installing water meters and charging according to use, designing plumbing fixtures and appliances that use less water, initiating public information programs, recycling municipal and industrial waste water, and by water pollution control.

Water use in manufacturing could be made more efficient through additional recycling procedures. Recent technological advances have allowed the steel industry to reduce water requirements by 90 percent in water-short areas. Perhaps the greatest saving can be achieved by reusing cooling water, which accounts for more than 65 percent of all industrial withdrawals.

Among the opportunities for increasing usable water supplies in a given area are: Interbasin transfers, desalting, precipitation modification, and watershed management.

The physical transfer of water from one watershed to another has been a common means of augmenting supply. For example, part of Denver's water supply comes from the Colorado River Basin, which is across the Continental Divide from Denver. Los Angeles imports water from the Great Basin, the Colorado Basin, and the Sacramento Basin. Each project must be evaluated on its individual merits. To properly evaluate interbasin transfers, it is necessary to examine the legal framework, the ways of protecting the exporting basin, the economics of the project, the social and environmental implications, and the institutional arrangements necessary to implement the project.

Because of increasing water demands and relatively fixed natural supplies of water, it is likely that desalting will become significant in the future, especially with smaller plants that have less than 10 million gallons per day capacity, in areas where alternative supplies are costly, where there are natural supplies of brackish water, where existing supplies need to be upgraded, or where point sources of dissolved solids can be treated. Desalting costs have been reduced from approximately $7.00 per 1,000 gallons in 1952, to approximately $1.00 per 1,000 gallons for seawater conversion, and $0.50 for brackish water plants at the present time. The projects that are energy-intensive will be less attractive as energy costs increase.[19]

The prospects for successful modification of rainfall and snowfall patterns to increase yields look promising. Cost estimates ranging from $1.00 to $2.30 per acre foot of additional runoff have been cited. However, these represent only the direct capital and operation costs, and do not include indirect economic environmental, or ecologically related costs. Uncertainties about both direct and indirect effects, as well as many legal and institutional implications have caused much controversy about precipitation modification. The National Water Commission concluded that precipitation modification has potential in certain limited areas, but available information is insufficient to develop a comprehensive national policy.

Forest and range lands are important sources of the Nation's water supply. Commercial and noncommercial forests occupy about one-third of the total land area of the Nation. Forest lands receive a yearly average of 42 inches compared to 24 inches annually on all other lands. Forest lands yield 17 inches of annual runoff compared to 4 inches from other lands.[20]

Watershed management of forest and range land can augment water supplies by enhancing the natural recharge of ground water, by slowing the rate of overland flow, and by improving the infiltration rate through proper vegetative and cultural practices.

Watershed protection and management is needed not only to ensure the optimum combination of water quantity and quality at a given location, but also to protect and enhance land resources such as soil and vegetation. For some situations, increasing the water supply through land management might be the best way to succeed. In other cases, these techniques create adverse side effects which should not be overlooked.

Small patchy openings created by timber harvests catch considerable quantities of snow, increasing water yields.

[19] Water policies for the future, final report to the President and to Congress, *op. cit.*

[20] Sopper, William E. Watershed management. Prepared for the National Water Commission. Natl. Tech. Inf. Service, Springfield, Va., No. PB206670. 2 p. 1971.

Most of the Nation's high-quality surface water comes from watersheds which support forest vegetation. Trees and other vegetation affect the water balance of a drainage basin in two ways. First, tree branches and leaves of plants may intercept up to 30 percent of total precipitation during light-intensity storms. This part of the precipitation is evaporated without adding to soil moisture storage. Second, plant roots absorb large volumes of soil water which are transported through the stem and removed through the leaves as transpiration. Since streamflow is a residual after all evaporative processes have been satisfied, early foresters and watershed scientists reasoned that water yield could be increased by reducing evaporative losses. Reducing vegetation density is the most efficient way to reduce evaporative losses.

Increases in streamflow after various intensities of forest cutting have been demonstrated in many parts of the country. Those individual studies have been summarized by Hibbert[21], Lull[22], Sopper[23], Douglas and Swank[24], and Anderson et al.[25] The following general conclusions have been presented:

1. Large increases in water yield following forest cutting occur in areas where (a) precipitation is abundant, (b) vegetation is dense, and (c) sufficient solar energy is available to evaporate large volumes of water.[26] The largest increases measured the first year after removal of all woody vegetation were 16.8 inches in western North Carolina,[27] and 18.2 inches in western Oregon.[28]

[21] Hibbert, Alden R. Forest treatment effect on water yield. *In* Forest Hydrology. William E. Sopper and Howard W. Lull (eds.), p. 527-543. Pergamon Press, New York. 1967.

[22] Lull, Howard W. Management possibilities for water yield increases. Proc. Joint FAO/USSR Int. Symposium on influences and watershed management, p. 168-178. 1970.

[23] Sopper, W. E. Watershed management: water supply augmentation by watershed management in wildland areas. Report to the National Water Commission. Natl. Tech. Inf. Service, Springfield, Va. 149 p. 1971.

[24] Douglas, James E., and Wayne T. Swank. Streamflow modification through management of eastern forests. U.S. Department of Agriculture, Forest Service. Research Paper SE-94, 15 p. 1972.

[25] Anderson, Henry W., Marvin D. Hoover, and Kenneth G. Reinhart. Forests and water: effects of forest management on floods, sedimentation, and water supply. U.S. Department of Agriculture, Forest Service. General Tech. Rep. PSW-18, 115 p. 1976.

[26] Lull, *op. cit.*

[27] Hoover, M. D. Effect of removal of forest vegetation upon water yields. American Geophysical. Union Transactions, 6:969-975. 1944.

[28] Rothacher, Jack. Increases in water yield following clear-cut logging in the PNW. Water Resources Research, 6:653-658. 1970.

2. Selective tree cutting has little or no effect on water yield unless the cutting intensity exceeds 20 percent.[29]
3. When the cutting intensity exceeds 20 percent, water yield increases are proportional to the percentage reduction in growing stock. Maximum yield increases are achieved by clearcutting.[30]
4. In the eastern hardwood region, water yield increases are maximum the first year after timber harvesting; increases gradually diminish as the forest is regenerated.[31] The duration of yield increases after clearcutting in the eastern hardwood region is highly variable. The longest time for a clearcut experimental watershed is about 40 years; the shortest about 5 years.[32]
5. In the mixed conifer zones of the Rocky Mountains, the most efficient way to increase water yield is removing the trees in small patches which together occupy about half of the watershed area.[33] Because of slow regrowth and snow redistribution into the small openings, yield increases are expected to persist for up to 40 years.[34]
6. Water yield increases after forest removal are greatest in year of abundant precipitation and least in years of drought, especially in regions where evapotranspiration exceeds moisture supplies.[35]
7. Because deciduous trees are dormant for part of the year and thus use less water than conifers, converting from deciduous species to conifers reduces the annual water yield.[36]
8. In areas where moisture supplies are limited during the growing season, converting from deep-rooted native species

[29] Hibbert, *op. cit.*

[30] *Ibid.*

[31] Kovner, J. L. Evapotranspiration and water yields following forest cutting and natural regrowth. Society of American Foresters Proceedings. p. 106-110. 1956.

[32] Douglass and Swank, *op. cit.*

[33] *Ibid.*

[34] *Ibid.*

[35] Lull, Howard W., and K. G. Reinhart. Increasing water yield in the Northeast by management of forested watersheds. U.S. Department of Agriculture, Forest Service, Res. Pap. NE-66, 45 p. 1967.

[36] Swank, Wayne T., and James E. Douglass. Streamflow greatly reduced by converting deciduous hardwood stands to pine. Science, 185: 857-859. 1974.

such as chaparral to a shallower-rooted species such as grass causes increases in water yield.[37]

Water yield from headwater streams can be augmented by reducing vegetation density by 20 percent or more. The following sections explore the inherent potentials in the forest and range environment for increasing regional water supplies. None of these estimates fully consider all the many environmental issues involved.

In one study,[38] the energy balance method was used to estimate the potential for augmenting water supplies through forest management in States east of the Mississippi River. Estimates from this study are adjusted here in table 7.15 to include all of the forests east of the 100th Meridian. These values are based on the assumption of complete forest regulation for increased water supplies and a rotation age of 120 years.

The values in table 7.15 are considered applicable to regions but not necessarily to individual watersheds. It has also been estimated that even-age management of some Southeastern watersheds could increase water yield considerably more than the values in table 7.15.[39]

Timing of increased water yield is important if reservoirs are not available to store the extra water until it is needed. Research in the East indicates that a large part of the increased flow occurs in later summer when flow is normally lowest.[40] Some streams which dry up in late summer flow continuously after vegetation on the basin is removed.[41]

Table 7.15 — *Estimated potential for increasing water yield from forested lands in the eastern States*

Forest type	Forest area	Average annual yield increase	
	Thousand acres	*Inches*	*Thousand acre-feet*
White-red-jack pine	12,666.7	0.45	475
Spruce-fir	21,484.5	.60	1,465
Longleaf-slash pine	17,316.6	.30	433
Loblolly-shortleaf pine	50,245.1	.35	1,465
Oak-pine	34,948.6	.20	582
Oak-hickory	115,268.7	.10	961
Oak-gum-cypress	29,380.9	.20	490
Elm-ash-cottonwood	26,120.5	.20	435
Maple-beech-birch	35,271.6	.15	441
Aspen-birch	20,582.1	.10	172
Total	373,285.3	2.65	6,528

The potential for augmenting water supplies in the western United States has received considerable attention during recent years and estimates vary according to the assumptions used. An intensive study by a U.S. Senate Select Committee[42] evaluated the opportunity for increasing water supplies in the 17 western States through vegetation management. This study indicated a potential initial water yield increase of about 12 million acre feet per year. Another study[43] estimated that, in the western States (exclusive of the Pacific coastal areas), the potential annual increase in water yield from all cover types with sustained yield and multiple-use considerations, but with intensive management for water yield improvement, would be about 4.1 million acre-feet above natural levels. The estimated average annual cost of producing this much water was $21.42 per acre foot at 1967 price levels. However, the greatest potential appeared on commercial forest land; intensive management for water yield of about 66 million acres of commercial forest land in the West could potentially increase annual water yield by 1.8 million acre-feet at a 1967 equivalent cost of $1.23 per year per acre-foot.

In a more recent analysis, the potential for increasing water supplies in Oregon, Washington, Idaho, Alaska, and (northern) California was estimated.[44] These estimates, by precipitation zone and timber type, are presented in table 7.16. The values are based on the following assumptions: (1) Water yield increases from small experimental watersheds can be expanded to large areas, (2) rotation age will be shortened and the harvest of old-growth inventory will accelerate, and (3) the forest harvest will be by clearcutting.

[37] Hibbert, Alden R., Edwin A. Davis, and Thomas E. Brown. Managing chaparral for water and other resources in Arizona. Proc. Watershed Management Symposium, ASCE Irrigation and Drainage Division, Logan, Utah, p. 445-468. 1975.

[38] Lee, Richard. Opportunities for increasing water supplies in the eastern United States by vegetation management. Unpublished Rep. On file at the Forest Hydrology Laboratory, Wenatchee, Wash., 78 p. 1977.

[39] Anderson, Hoover, and Reinhart, *op. cit.*

[40] *Ibid.*

[41] Kochenderfer, James N., and Gerald M. Aubertin. Effects of management practices on water quality and quantity: Fernow Experimental Forest, West Virginia. *In* Municipal Water Management Symposium Proc., U.S. Department of Agriculture, Forest Service. General Tech. Rep. NE-13, p. 14-24. 1975.

[42] U.S. Senate Select Committee on National Water Resources. Water resources activities in the United States: Evapotranspiration reduction. Part 2: Vegetation management. Comm. Print No. 20, 86th Congress, 2nd Session, p. 13-42. 1960.

[43] Reigner, I. C., R. C. Maloney, and E. G. Dunford. Unpublished Rep. On file at U.S. Department of Agriculture, Forest Service, Washington, D.C. 1969.

[44] Wooldridge, David D. Opportunities for increasing water supplies in the Pacific Coast States by vegetation management. Unpublished Rep. on file at the Forest Hydrology Laboratory, Wenatchee, Wash., 130 p. 1978.

Table 7.16—*Summary of estimated annual yield increases which could be achieved in the Northwest through vegetation management*

Hydrologic zone	Vegetation type	Annual yield increase
		Thousand acre-feet
1. Coastal rain zone	Douglas-fir, hemlock, Sitka spruce	2,100
2. Puget-Willamette rain zone	Douglas-fir, hardwoods	400
3. Warm snow zone	Fir-spruce)	
4. East Cascades snow zone	Ponderosa and lodgepole pine)	2,570
5. Interior cold snow zone	Douglas-fir, lodgepole pine,) ponderosa pine, white pine)	
Total		5,070

Source: Wooldridge, David D. Opportunities for increasing water supplies in the Pacific Coast States by vegetation management. Unpublished rep. on file at the Forest Hydrology Laboratory, Wenatchee, Wash., 130 p. 1978.

Timing of increased yield in the Northwest varies with the precipitation zone. In the rain zones, about 80 percent of the increase occurs during the wet winter months.[45] Increases amounting to 0.8 inches during the low flow months of July-September[46] are important for instream needs. In the snow zones, most of the yield increase occurs during spring snowmelt.

Estimated potentials for increasing water yields in the commercial forests of the western States by timber type are summarized in table 7.17. These values are based on several summary reports.[47, 48, 49, 50] The estimated increases are based on the difference between no management and specific management for water yield increases.

The chaparral type, which contains several species of shrubsize plants, covers approximately 29 million acres in southern California, Arizona, and New Mexico. Intensive research during the past few years indicates that opportunities for increasing water supplies from the chaparral type are excellent under certain conditions. In areas where shrub cover exceeds 30 percent, average annual precipitation exceeds 16 inches, and soils are deep, substantial increases in water supplies can be produced.[51] The most effective treatment is to eradicate the shrubs from about 60 percent of the total treatable area and

Table 7.17 — *Estimated potential for increasing water yield from forested lands in the western States*

Forest type	Forest area	Average annual water yield increase	
	Thousand acres	*Inches*	*Thousand acre-feet*
Douglas-fir	38,240.2	0.60	1,912
Ponderosa pine	33,670.7	.15	420
Western white pine	565.9	.45	21
Fir-spruce	113,362.9	.60	5,668
Hemlock-Sitka spruce	20,139.9	.45	755
Larch	2,807.2	.30	70
Lodgepole pine	21,217.6	.25	442
Redwood	786.0	.45	29
Total	230,790.4	—	9,317

Source: Forest Service estimates derived from:
Hibbert, Alden R. Vegetation management for water yield improvement in the Colorado River Basin: summary and assessment. Rocky Mountain For. and Range Exp. Sta., (in press) Wooldridge, David D., see source note table 7.16; Leaf, Charles F. Watershed management in the central and southern Rocky Mountains: A summary of the status of our knowledge of vegetation types. U.S. Forest Service, Res. Paper. RM-142, 28 p. 1975; and Sopper, W. E. Watershed management: water supply augmentation by watershed management in wildland areas. Report to the National Water Commission. NTIS, Springfield, Va. 149 p. 1971.

establish a grass cover. Research has demonstrated that wildlife benefits from these treatments and that fire protection is made easier.[52] An economic analysis with actual conversion costs and assumed benefits indicated a net average annual return of $2.51 per converted acre based on 1972 prices.[53] It is estimated that the annual cost of water production in the chaparral type is $20.45 per acre-foot in California and $18.00 per acre-foot in the Southern Rocky Mountain region, based on 1967 price levels.[54]

[45] Rothacher, *op. cit.*

[46] *Ibid.*

[47] Wooldridge, *op. cit.*

[48] Hibbert, Alden R. Vegetation management for water yield improvement in the Colorado River Basin: Summary and assessment. U.S. Department of Agriculture, Forest Service, Rocky Mtn. Forest and Range Exp. Sta. (In press).

[49] Leaf, Charles F. Watershed management in the central and southern Rocky Mountains: A summary of the status of our knowledge of vegetation types. U.S. Department of Agriculture, Forest Service. Res. Pap. RM-142, 28 p. 1975.

[50] Sopper, W. E., *op. cit.*

[51] Hibbert, Davis, and Brown, *op. cit.*

[52] *Ibid.*

[53] *Ibid.*

[54] Reigner, et. al., *op. cit.*

If a major program is implemented to increase water yield from the entire chaparral area, about 6 million acres could be converted to grass cover. The increase in water yield would average about 1.2 million acre-feet each year. The median value, based on measured run-off in Arizona, would be about 0.7 million acre-feet.

Other prescriptions in the Southwest would, if implemented, augment surface water supplies. One practice which has received considerable study is the eradication of phreatophyte vegetation along streams. Under certain conditions, phreatophytes transpire up to 6 or 7 acre-feet of water per acre of surface area.[55] Eradicating deep-rooted plants and substituting shallower rooted species in areas where water tables are a few feet below the surface can save part of this water. To be effective, the cleared area must be mowed, plowed, or sprayed with herbicides periodically to prevent the deep-rooted vegetation from recapturing the site.

It is estimated that an intensive phreatophyte eradication and control program applied on 8 percent of the areas occupied by phreatophytic vegetation would save 0.9 million acre-feet of water each year.[56] The cost of clearing, control, and maintenance was estimated at $14.00 annually for each acre-foot of water produced.

The opportunity to increase water yield from areas supporting sagebrush and pinyon-juniper is minimal because of the dry climate.

Estimates of increased water supplies presented here are based on the expected difference in runoff between no forest management and specific management for water yield increases. The values presented in table 7.15 through 7.17 should be considered as the upper limits which could theoretically be achieved and not the expected changes which will be produced and sustained through planned environmentally acceptable multiple-use management over the next half century.

Flood Damage Management

The Department of the Army and the Department of Agriculture have active flood control, flood prevention, and watershed protection. Expenditures on structural measures such as dams, levees, and channels installed under these programs have averaged over $600 million per year over the last 10 years. There are, of course, many additional opportunities for flood control structures. For example, a recent analysis[57] indicated that it should be possible to reduce annual losses by at least 20 percent if these structures could be built rapidly and cheaply enough.

In recent years, increasing emphasis has been placed on the use of nonstructural measures to mitigate flood damage. These nonstructural measures include flood insurance; flood-proofing of structures; flood plain regulation; acquisition of flood plain lands for recreation, fish and wildlife, and other public purposes; public information programs; tax incentives; and improved forecasting and warning systems.

In many cases, a combination of structural and nonstructural measures will likely be most effective. Programs that are developed should give full consideration to the specific situation being faced, and the attendant decisions should be focused on meeting specified objectives at the lowest possible cost.

A land treatment program should be part of any flood management effort. Proper watershed protection helps reduce flooding by reducing or delaying the sedimentation of flood-retarding structures and stream channels. Land treatment can also affect the amount and rate of flood run-off and can complement other structural and nonstructural measures.

One opportunity to reduce flood damages is to remove floatable debris from flood plains. This is especially true for floods with recurrence intervals of up to 25 years, where most debris is lying loose in the flood plain before the flood occurs. For floods with longer return periods, much of the debris is made available to the flood, for example by the water undercutting banks, so large trees and brush are dropped into the floodwater and carried downstream. Debris left by logging, land clearing for development, construction, or other services could be removed through the various manpower programs of public service groups. Increased technical and financial assistance to owners of private forest and range land also could reduce the amount of floatable debris. More importantly, education of groups or industries that create this debris could prevent much of the debris from accumulating.

Pollution Control — Point Source

The strategy for controlling point source pollution has undergone a major change since the late 1960's when large scale pollution control efforts first began. The initial efforts in controlling pollution from municipalities and industries were based on maintaining

[55] Horton, Jerome S., and C. J. Campbell. Management of phreatophyte and riparian vegetation for maximum multiple use values. U.S. Department of Agriculture, Forest Service, Research Paper RM-117, 23 p. 1974.

[56] Reigner, Maloney, and Dunford, *op. cit.*

[57] White, Gilbert F., and J. Eugene Hass. Assessment of research on natural hazards. The MIT Press, Cambridge, Massachusetts. 1977.

the existing quality of receiving waters. With the passage of the Federal Water Pollution Control Act Amendments of 1972, however, the control was shifted to effluent standards that were developed for each category of discharger. Under the provisions of this act, the Environmental Protection Agency instituted the National Pollutant Discharge Elimination System, a permit system that regulated each point discharge in terms of the quantity of each specified pollutant. This shift in strategy and the implementation of the permit system enabled water quality to be improved rather than simply maintained.

The Clean Water Act of 1977 (P.L. 92-217) has further refined the strategy controlling point source pollution. Municipalities are now required to provide waste treatment at least equivalent to secondary treatment by using the most practicable waste treatment technology. Also, industries are required to use the best technology economically available for toxic pollutants and the best conventional pollutants and control technology for conventional pollutants. Permits for regulation are still to be issued under the National Pollutant Discharge Elimination System to potential polluters, be they individuals, corporations, municipalities, or State or Federal agencies.

Section 208 of the Federal Water Pollution Control Act Amendments of 1972 also requires water quality management plans that: (1) Identify areas in need of municipal and industrial waste treatment facilities, (2) establish priorities for constructing such facilities, and (3) identify the nature, scope, and extent of nonpoint sources of water pollution as well as ways to control them. Though the "208" plans have not been completed, the National Pollutant Discharge Elimination System has been effective in reducing point source pollution. For example, construction of another municipal waste treatment facility may no longer be as beneficial to water quality as implementing practices to control nonpoint source pollution on some stream segments. Although point sources are more easily controlled than nonpoint sources, it is generally more expensive to do so, and control of the last portion of point source pollution may not be cost-effective with respect to the nonpoint source pollution.

Pollution Control — Nonpoint Source

It is inevitable that water quality objectives will have an increasingly important role in the management of forests and rangelands, especially with respect to nonpoint sources of pollution. Through Section 208 of the Federal Water Pollution Control Act Amendments, efforts are being made to identify the sources of nonpoint pollution, to determine the extent and impact of these pollutants on water quality, and to prescribe control methods. Nonpoint source pollution control is primarily a State responsibility for which the States are preparing "208" plans. Whereas previous nonpoint pollution control efforts were aimed at meeting individual States' water quality standards, the Clean Water Act of 1977 recognized the concept of best management practices as an acceptable approach to controlling this type of pollution. The Clean Water Act also recognizes that land management must be practiced if we are to continue to provide an adequate supply of food, fiber, and minerals.

Best management practices are designed to prevent as much pollution as possible from entering a stream or lake. Nonpoint source pollution is diffuse, so collection and treatment is difficult and expensive, if not impossible. Even where nonpoint source control projects are deemed economically and technically feasible, they may not be warranted on some stream segments because pollution from natural, uncontrollable sources will prevent the achievement of some goals stated in the Federal Water Pollution Control Act Amendments.

Best management practices with respect to forests and rangelands must address the various activities that take place on these lands, including logging, road construction, treatment of vegetation by cutting or burning or by use of pesticides or fertilizers, outdoor recreation, grazing of livestock and wildlife, and off-road vehicle use. If best management practices are to be effective, they must be defined and accepted by Federal and State agencies in cooperation with private industry, organizations, and individuals.

However, three important concerns relating to best management practices still must be addressed: (1) The definition of the practices must fit local conditions; (2) standards must be set to judge compliance and to evaluate effectiveness; and (3) it must be determined if best management practices constitute compliance with relevant State water quality standards. A recent survey of streamside management zone statutes and ordinances indicated that "pollutant levels from nonpoint sources have not been adequately quantified in such a way as to become standards for inclusion in legislation."[58]

On most public lands, best management practices will be defined by appropriate Federal and State agencies and incorporated into land and resource

[58] U.S. Department of Agriculture, Forest Service, and the U.S. Environmental Protection Agency. Streamside management zone, statutes and ordinances. Criteria and institutional arrangements serving water quality objectives on State and Private forest lands. U.S. Gov. Printing Office, March 1978.

management plans. Logging contractors, grazing permittees, and other "permitted" users will be subject to the performance standards specified. Technical assistance and consultation are available from land management agency personnel.

There is a need for considerable technical and financial assistance to implement best management practices on privately-owned forests and rangelands. The Rural Clean Water Program established under the Clean Water Act and the Cooperative Forestry Assistance Act (P.L. 95-313) both provide for this type of assistance. The Rural Clean Water Program is expected to provide for cost-sharing contracts with individual landowners for installing best management practices in accordance with approved "208" plans in 1979. This would be the first large-scale appropriation earmarked for control of nonpoint source pollution. Work done under this program will be on a priority basis and by project area as identified in the State plans.

The Cooperative Forestry Assistance Act provides for technical and financial assistance to protect or improve soil fertility on non-Federal fórest lands, and the quality, quantity, and timing of water yields. Although the guidelines have not yet been prepared for this Act, it is assured that practices to achieve these objectives will first be carried out on high priority areas.

The cost of significantly reducing all aspects of nonpoint source pollution across the Nation is not known, but the figure is very high. For example, in Iowa, a State program pays at least 75 percent on a cost-sharing basis to implement permanent soil and water conservation practices. Iowa has estimated that it would cost nearly $1.7 billion to install necessary soil erosion measures. Other sources of nonpoint pollution would be reduced only incidentally as they are related to sediment. The State of Pennsylvania estimates that 2,021 miles of major streams need rehabilitation because of acid drainage from abandoned mines, sometimes combined with other pollutants. Officials there estimate that $3 billion is needed to restore them. Again, other nonpoint source pollutants are only affected incidentally.[59]

Clearly, the best control practice for nonpoint source pollution is to prevent those pollutants from entering a stream or lake. Prevention is also much more cost-effective than restoration.

Technical and Financial Assistance

Fifty-five percent, or nearly 860 million acres, of the Nation's forest and range land is in State or private ownership. In many watersheds and river basins, especially in the eastern United States, this proportion is significantly greater. By virtue of this proportion alone, these lands have important implications for the management of water and related land resources. The management or mismanagement of these lands can, and does, have a significant impact on water quality and sedimentation of stream channels and reservoirs, and can significantly increase or reduce the productivity and fertility of soils.

Private landowners have several opportunities to receive technical or financial assistance or both for water and related land resource problems. Local organizations, within authorized watershed projects, need help in planning and installing forestry measures for watershed protection and flood prevention. Assistance is also needed by Federal-State-local groups to investigate the conservation, development, and management of water and related resources on a river basin basis. Many rural communities need assistance in improving local economic, environmental, and social situations through the orderly development, improvement, conservation, and use of forest and related resources. Individual owners and municipalities need assistance in designing best management practices to reduce nonpoint source pollution and to protect or improve soil fertility and the quality, quantity, and timing of water yields from non-Federal forest lands. These or other natural elements also create a need for emergency planning and treatment to improve or restore the hydrologic condition of impaired watersheds.

Research

Research has contributed greatly to the progress and accumulated knowledge related to managing this Nation's water and related land resources. Considerable information is now available for assessing water supply and distribution, trends in consumptive and nonconsumptive use, seasonality problems, and water quality. Additional research on forest and range lands is needed, however, before methods are devised to alleviate other water-related problems:

1. Research on techniques to reduce consumptive use. A number of approaches can be used, including riparian zone management, more efficient irrigation methods, development of effective and practical evaporation suppressants, and vegetation management to minimize evapotranspiration. For example, current knowledge is limited on how the composition and density of vegetative cover influence surface runoff. Needed

[59] The Comptroller General of the United States, *op. cit.*

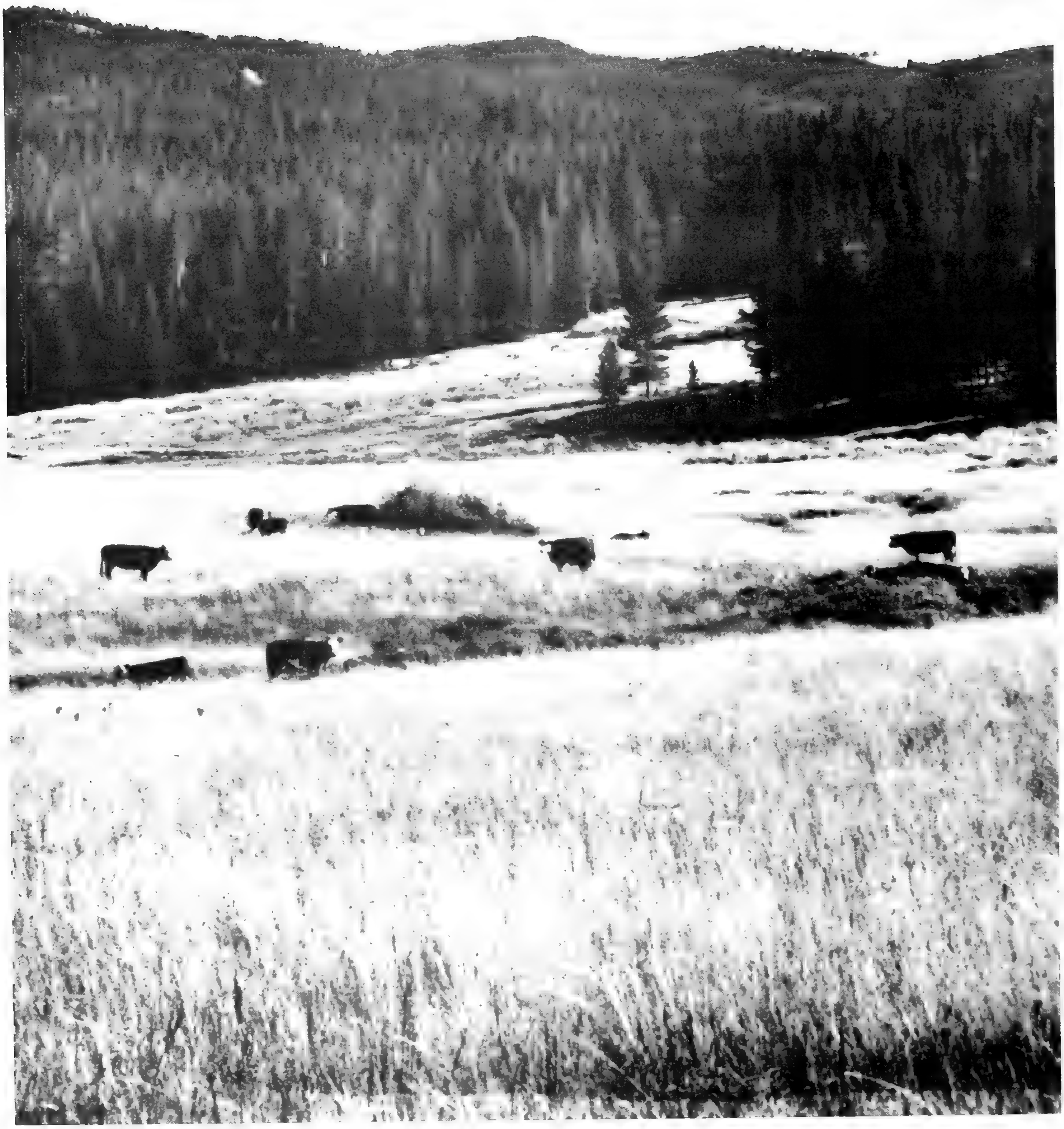
is a better understanding of how water yield is influenced by manipulating vegetation growing under different soil and climatic conditions. Also needed are practical methods for the land manager to achieve satisfactory water yields.

2. Snow management to control snow accumulation and snowmelt. More knowledge is needed on synthesizing meteorology data with vegetative management and the design of engineering structures to influence snow deposition, snowpack stability, and rate of snowmelt. Better methods for reducing sublimation and evaporation losses are needed.
3. Flood control-abatement through use of construction works and vegetation management and protection of flood-prone areas from economic loss. Expanded research is needed in many areas to develop management practices for the riparian zone to sustain and protect water resources, esthetics, wildlife habitat, and recreation values.
4. Reduction of nonpoint source pollution to enhance water quality. Many areas need study, including erosion and sedimentation control, identification of basic contributors to nonpoint source pollution, nutrient cycling processes, atmospheric deposition, land management alternatives, insect and disease, fire, and the use of fertilizers and pesticides. Although research has been concerned with alleviation of pollution resulting from forestry practices — including prescribed fire, road construction, pesticide use, and mining on forests and rangelands, additional studies in these areas are needed. New research should focus on: (a) The nature, extent, and effects of pollutants resulting from intensive timber culture; (b) development of standardization procedures for predicting pollutants resulting from various land use practices; and (c) establishment of guidelines and practices to minimize water pollution from forestry activities.
5. Reclamation of disturbed lands. Intensified research is needed on developing methods to minimize watershed damage during exploratory testing, surface mining activities, and other land-disturbing operations. Advanced methods in land forming and rapid revegetation under a wide range of climatic, topographic, geologic, and soil conditions are needed. Objectives should include protecting the quality and quantity of existing surface and ground water supplies, conserving water during land-disturbing and rehabilitation operations, and increasing available supplies where feasible.
6. Treatment and disposal of wastes on land. Land areas are increasingly sought for treatment and disposal of effluents, sludges, and other wastes. More research is needed on techniques for land disposal of various wastes while maintaining watershed values, including protection of water quality and possible enhancement of water availability by effluent irrigation.
7. Taiga hydrology in Alaska. Additional research is needed to develop land management practices for protection of water resources in central Alaska. Data developed would be applicable to about 100 million acres.
8. Acid precipitation — causes, effects, and control. Little attention has been given to this problem. Preliminary research shows a continual degradation in precipitation quality in much of the United States. Concern has been raised about possible adverse effects on forest and aquatic ecosystems. Acid precipitation is most evident in the Northeast, but is spreading to other parts of the Nation.
9. Insect and disease protection. Techniques need to be developed to evaluate how damage caused by insects, diseases, and air pollutants relates to the quality and quantity of water produced. Research is also needed to develop pest management systems consisting of various techniques and strategies to regulate impacts of insects and diseases on water quality and land uses and values. For example, improved survival and growth of many woody plants on harsh disturbed areas can result from introduction of mycorrhizal fungi. Also to be learned is the influence of various pollutants on air quality and the sec-

ondary influence they have on land and water through their effect on tree cover.

10. Protection from fire. Runoff from severe storms on repeatedly burned watersheds has been found to be as much as 500 times that of adjacent undisturbed watersheds. For many public and private land managers, erosion from burned watersheds is a very important factor in the productivity of their management units because of accelerated surface erosion and loss of top soil following fire. Research must provide the fire manager with the information needed to make wise strategic and tactical decisions in the protection of watersheds. For the most part, these are the same kinds of information needed in managing timber lands. Additional information includes a knowledge of the ecology of relatively short-lived shrub species. Many chaparral species are relatively nonflammable in their youth, but when they achieve middle or old age, go into a period of decadence in which large quantities of dead fuel accumulate within the individual plants. At this period, they become extremely flammable. Research may be able to provide fire managers with techniques to selectively burn chaparral or other brush areas so that the vegetative cover is continually kept in a less flammable condition. In some semiarid locations, riparian vegetation results in a serious water loss. Research can provide fire managers with the knowledge and tools needed to manipulate this vegetation. At the other extreme, fire can be used to manage vegetation in the snow zone, allowing more accumulation and slower melt.

In a broad sense, research is the key to providing the most desirable mix of water quality and quantity production with the protection of vital natural resources, and esthetic, social, and economic values.



Chapter 8. — Multiple Resource Interactions

In examining supply trends and opportunities to enhance supplies of individual resources, the previous chapters did not deal with the complex interactions among resources because quantitative information on renewable resource interactions is limited. Many studies have examined the interaction between two resources over a small geographic area. These studies are of little use, however, in quantifying the impacts of resource interactions for a national assessment. In spite of the difficulty of quantifying multiresource interactions, it is essential to understand the potential impacts of meeting future demand for one resource on the capacity to increase supplies of other resources. Analyses suggest that, with more intensive management, supplies can be increased to meet nearly all renewable resource products, but still to be examined is the potential for meeting the combination of resource demands from the resource base at reasonable cost or without extensive environmental degradation.

This chapter discusses the complexity of estimating multiresource interactions, introduces an analytical model which has the potential for quantifying these interactions at regional and national levels, and evaluates the capability of forest and range land to increase supplies of renewable resource products.

Complexity of Estimating Renewable Resource Supplies

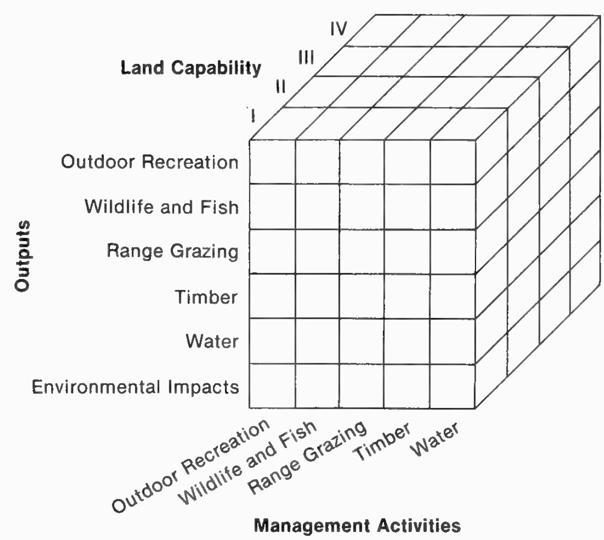
The individual resources and uses discussed earlier occur not in separate places on forest and range lands, but rather in a great variety of combinations and under a wide range of conditions. Land and resource managers deal with this complexity along with additional complicating factors such as different ownerships and management goals. In some instances, the production of two resources on an individual unit of land is complementary. That is, management activities to increase the production of one resource will also increase the supply of the other. In other instances, the two resources may be competitive. Increases in the supply of one can only be accomplished at the cost of a reduction in the amount available of the other. To fully evaluate the productive capacity of a tract of land, it may be necessary to understand the interactions among several resources. For example, it may be desirable to know what combinations of timber forage for domestic livestock and forage for wildlife can be grown. Further, it may be desirable to know the impact of these various combinations on storm runoff and contribution of sediment to an adjacent stream. On any particular area, interactions occur simultaneously in at least two directions. That is, timber management actions will affect the recreation resource, while at the same time, recreation management activities will affect timber production. These kinds of multiple interactions are common on all forest and range lands. To make a decision about the type of management activities needed to obtain a given set of desired outputs, the interactions among these uses must be evaluated.[1]

For each resource, various activities are carried out as a part of management. For example, "timber stand improvement" is a management activity—or, more properly, a category of activities—commonly practiced as timber management. Each activity—directly or in combination with other activities—is intended to bring about specific results measured in terms such as animal unit months, million cubic feet of timber, or recreation visitor days. In addition to the primary intended result, there is normally a wide array of associated results. To carry the example further, timber stand improvement might result in increasing the forage available for wildlife and reducing the length of time snow will remain on the ground as well as the primary result of increasing net growth of usable timber.

Diagrammatically, these interactions can be illustrated as shown in figure 8.1.

[1] Cooper, C. F. Ecosystem models in watershed management. *In* The ecosystem concept in natural resource management. G. M. Van Dyne (ed). Academic Press, New York. p. 309-324, 1969.

Figure 8.1



For every management activity, there are potential impacts on each of the resource outputs and associated environmental effects. These will vary with the characteristics of the land on which the activity is applied. This diagram is misleadingly simple from the perspective of a national assessment. The variations in land capability, existing resource conditions, and potential management practices combine to form many thousands of potential output combinations even at a highly aggregated level of analysis.

Quantifying Multiple Resource Interactions

It is necessary that these multiple resource interactions be quantified to determine whether the Nation's forest and range lands can meet projected resource demands at reasonable costs, both monetary and environmental. A recently developed computerized analytical model has the potential of quantifying resource interactions at the regional level.[2] This model was developed in response to the need for a systematic way to measure the impact of changes in the level of any one or any combination of outputs or services on the ability of the forest and range land system to produce the remaining outputs or services.

In this model, the degree of interaction among the the various resources is measured by the impact that increasing one output has on the costs of producing the remaining products. Using timber and range, for example, the model will aggregate for a region those areas where increasing the region's softwood timber supply raises the cost of producing an increment of range grazing (in circumstances where the two resources are competitive); it will also aggregate those areas where increasing the timber supply lowers the cost of providing an increment of grazing (in circumstances where the two resources are complementary). For purposes of this Assessment, the model considers the interactions between changes in softwood timber, hardwood timber, range grazing of domestic animals, dispersed recreation, wild ruminant grazing, water yield, sediment, and storm runoff.

For use of this model, the forest and range land base was divided into approximately 5,000 resource units. Resource units are a means of categorizing land by its potential natural community, ownership (four classes), productivity (four classes), and stocking condition (four classes). For each resource unit, a set of management levels was identified by combining specific activities from a list of 53 management practices. Different management levels emphasize different management objectives and give preference to different resource outputs.

In the absence of research studies which could be used to estimate the outputs from all appropriate management levels applied to each resource unit, the best current information was gathered from knowledgeable professionals. The basic premise of this data collection effort was that such people with strong backgrounds in applied research and resource management could jointly specify production coefficients of the land base to form a consistent data base suitable for evaluating natural resource use potential at a national level.

Thirteen output measures from the process were used in the analysis:

1. Herbage and browse production measured in pounds/acre/year;
2. Net wood growth measured in cubic feet/acre/year;
3. Wood harvested measured in cubic feet/acre/year;
4. Domestic livestock grazing measured in animal unit months (AUM)/acre/year;
5. Wild ruminant grazing measured in animal unit months (AUM)/acre/year;
6. Dispersed recreation use measured in visitor-days/acre/year;
7. Water yield measured in inches/year;
8. Storm runoff measured in inches/year;
9. Sediment yield measured in tons/acre/year;
10. Life form-water measured by percent of area;
11. Life form-ground measured by percent of area;
12. Life form-shrubs measured by percent of area;
13. Life form-trees measured by percent of area.

For the analysis which follows, output and cost estimates were converted to reflect the average output and costs over a 50-year management period. This conversion reflected the transition of lands to new condition classes over this period of time.

This information was used as input to a linear programming model to determine the level of management for each resource unit that would minimize the cost of producing targeted levels of outputs of timber and range products while maintaining levels of other goods and services.

Implications of Meeting Projected Regional Timber and Range Grazing Demands

To illustrate the usefulness of this interaction model, this section discusses the implications of

[2] Ashton, Peter, James Pickens, Coryell Ohlander and Bruce Benninghoff—Many resources, many uses: a system analysis approach to current and future renewable resource development. Paper presented at the 15th Annual Conference of the American Water Resources Association, Las Vegas, Nevada. September 24-28, 1979.

meeting projected regional timber and range grazing demands, and their impact on other resource uses, environmental effects, intensity of land use, and costs. The demands for timber and range grazing serve as the basic output requirements which the model must achieve. The model incorporates a technique for estimating the change in wild ruminant grazing, water yield, dispersed recreation use, and sediment yield. Wild ruminant grazing and dispersed recreation are produced to the level where the cost of one more unit of that output would have been greater than its benefit value.[3,4] The results of the model for the Southeast region will be shown in some detail. Only highlights of applying the model to the other regime will be given here.

Southeast.—Sample results from the model of supplying targeted timber and range grazing amounts in 1985 and 1995 in the Southeast are shown in table 8.1. Some of the impacts illustrated by this table are:

- In addition to meeting timber and range targets in 1985, dispersed recreation can be increased by 10 percent more than 1977 with the marginal benefits equalling marginal costs. However, in order to meet the 1995 targets for timber and range, dispersed recreation use will have to drop below the 1977 use by 4 percent.
- The impact of meeting the required targets are either beneficial or negligible on herbage and browse production, wild ruminant grazing, water yield, and storm runoff.
- Increased timber harvesting and grazing by 1985 and 1995 will require moving to lands which are more susceptible to erosion and therefore result in substantially increased sediment yields.
- Meeting the timber and range targets plus increasing dispersed recreation to the point where marginal costs equal marginal benefits requires intensification of management. While only 11 percent of the National Forests were managed intensively in 1977 (according to the definition of "intensive" used for model specification), 23 and 28 percent will have to be managed intensively by 1985 and 1995, respectively. Similarly, on State-owned or privately owned lands, 35 percent will require intensive management by 1995 compared to 22 percent in 1977.
- As management intensity increases and resources are supplied from less productive lands, the marginal costs of producing timber and range grazing will increase by substantial amounts.

South Central.—In the South Central region dispersed recreation initially displays a complementary relationship to the increasing demands for timber and range grazing, as recreation rises 49 percent by 1985. However, as timber and range demands increase beyond the 1985 level, dispersed recreation drops.

Herbage and browse steadily increase in response to the rising range grazing demand. Wild ruminant grazing rises continually throughout the projection period, suggesting that this resource use is complementary with increasing demands for timber and and range grazing. This relationship is the result of increased timber harvest which, in this region, apparently improves the opportunities for wildlife habitat.

Water yield and storm runoff are again very insensitive to the increases in timber and range grazing, a result of the geology, topography, and soil types of the region. However, sediment yield does rise substantially, as the acreage of intensive use increases to meet higher demands.

As in all other regions, the marginal costs of meeting timber and range grazing demands increase substantially.

North Central.—The model results indicate some important changes occur in the levels of resource use and environmental effects as a result of meeting the projected demands for timber and range grazing. Herbage and browse and sediment yield increase to a 1995 peak of 108 percent and 124 percent above the 1977 value, respectively. Sediment yield is primarily dependent on the total number of acres under treatment and associated intensive land use.

Water yield is apparently insensitive to changes in other outputs as it remains unchanged with time. Storm runoff rises slightly to a peak of 5 percent above the base year in 1995, due very likely to the increase in intensive land use necessary to meet range grazing demands.

The intensity of land use values remains virtually unchanged on National Forest System and other Federal lands. However, on State and private lands, which comprise about 80 percent of the region, the intensity of land use increases with demands.

The marginal cost of softwood timber remains unchanged over time, suggesting that the increasing demands are well within the productive capability

[3] The model restruction technique is discussed in Ashton, et. al., *op. cit.*

[4] For a discussion on benefit values see; Dyrland, Richard E., Working paper 1980 RPA value. Unpublished report on file at Washington Office, Forest Service, U.S. Department of Agriculture, Washington, D.C., May 8, 1979.

Table 8.1 — *Multiresource interactions in the Southeast resulting from meeting projected timber and range grazing demands*

Item	Units	1977	1985	1995
Projected demands:[1]				
Softwood timber	Billion cubic feet	—	2.42	3.06
Hardwood timber	Billion cubic feet	—	1.01	1.35
Range grazing	Million animal unit months	—	18.10	21.50
Resource use and environmental effects:				
Dispersed recreation use	Percent change from 1977	—	10.1	-4.0
Herbage and browse	Percent change from 1977	—	6.0	16.0
Wild ruminant grazing	Percent change from 1977	—	-0.3	2.0
Water yield	Percent change from 1977	—	0.4	1.0
Sediment	Percent change from 1977	—	89.0	116.0
Storm runoff	Percent change from 1977	—	0.3	0.1
Intensity of land resource used:				
National Forest lands:[2]				
Extensive use[3]	Percent of area	89	77	72
Intensive use[3]	Percent of area	11	23	28
Other Federal lands:				
Extensive use[3]	Percent of area	98	91	89
Intensive use[3]	Percent of area	2	9	11
State and private lands:				
Extensive use[3]	Percent of area	78	70	65
Intensive use[3]	Percent of area	22	30	35
Land resource use cost for all owners	Millions of dollars	—	647.4	985.1
Marginal cost softwood timber	Dollars per cubic foot	—	.16	.24
Marginal cost range grazing	Dollars per animal unit month	—	9.85	10.52

[1] Projected demands as shown in the review draft of this study.
[2] In this multiresource interaction analysis, the areas recommended for wilderness or further planning by the RARE II process were considered wilderness.
[3] The land resource use is said to be intensive if one or more of the timber, range, or wildlife activities of the resource management options are intensive. Timber activities are defined as intensive if intermediate treatments between regeneration and harvesting are conducted. Range activities are defined as intensive if practices, mainly species conversion, are made to maximize livestock forage production. Wildlife activities are defined as intensive if vegetative manipulation practices are undertaken to improve wildlife habitat. If none of the three activities are intensive, the use is considered extensive.

of the land base. Range grazing's marginal cost increases in 1995 in response to the associated increase in range demands.

Northeast.—The allocated demands for timber and range grazing in the Northeast are relatively small, and thus competition among the various resource uses is minimal.

The only substantial change occurs in herbage and browse, which rises above the 1977 value by 46 percent in 1995. This increasing trend for herbage and browse is in line with the rising range grazing demand levels and stable wild ruminant grazing levels.

Because of the slight increases in demands for timber and range grazing, the intensity of land use remains almost unchanged from base year levels. A slight increase in intensive use occurs on State and private lands, indicating that most of the demand increases will be met on these lands.

The marginal cost of timber remains unchanged throughout the projection period. This indicates that although timber demands increase, they remain well below the maximum timber production capability of the land base. However, the range grazing marginal costs show a fast climb. These large increases in marginal cost that result from small demand increases indicate that the range grazing demand may be nearing the maximum production capability of the Northeast.

Rocky Mountains-Great Plains.—The allocated timber demands on the Rocky Mountain/Great Plains regions rise less than range grazing demands. Therefore, range grazing increases have the greater impact on supply of dispersed recreation and other environmental effects. In addition to meeting the 1985 and 1995 timber and range grazing demands, the Rocky Mountain region is capable of increasing dispersed recreation use by 18 percent and wild ruminant grazing by 21 percent in 1995. There are

no major impacts on storm runoff or sediment yield.

Intensity of land use rises slightly on National Forest and other Federal lands, but increases much more significantly on Bureau of Land Management lands, and State and private lands, which comprise about two-thirds of the total land base in this region. As a result of this increased management, total costs increase. Likewise, the marginal costs for both timber and range grazing rise substantially with time.

Pacific Northwest.—In the Pacific Northwest, while the allocated softwood timber demands rise only slightly with time, the model results indicate meeting these demands induces some important changes in other resource use, and environmental effects occur. To meet timber and range grazing targets, dispersed recreation growth is limited to about 10 percent of the 1977 use, and wild ruminant grazing will fall below the 1977 level by the end of the projection period. On the other hand, water yield and storm runoff again show an insensitivity to changes in projected demands.

The intensity of land resource use figures reflects the increases in range grazing demands, as they rise significantly on State and private and Bureau of Land Management lands. Associated with these increases in intensity of land use is a rise in total land resource use cost. As expected, the marginal cost for timber increases only slightly, in response to the similar small rise in timber demands. The range grazing marginal cost increases rapidly.

Pacific Southwest.—The allocated demand for softwood timber and range grazing in the Pacific Southwest increases with time, but at a lower rate than in most of the other regions. However, some significant changes in resource use and environmental effects accompanied the meeting of these projected demands.

Dispersed recreation can be increased by 46 percent during the projection period. This trend indicates that dispersed recreation use can be increased while meeting projected demands for timber and range grazing. Herbage and browse increase slightly with time, a result of the management practices necessary to meet range grazing demands. A slight reduction in dispersed recreation signals possible increased competition as projected demands rise. Wild ruminant grazing rises by 17 percent in 1985, but then drops. Range and wild ruminant grazing production begin to compete at higher levels of range grazing demand. The hydrological outputs, water yield, sediment, and storm runoff display little sensitivity to the projected demand changes in this region, a result both of the low demand increases and the characteristics of the local geology, topography, and soils.

Examination of the intensity of land resource use data shows a very substantial rise in intensive use of National Forest and especially State and private lands, compared to little change in intensity on Bureau of Land Management or other Federal lands.

Despite the large increases in intensive use, total land resource use cost rises over the projection period. This moderate rise is necessary to meet the increased timber and range grazing demands. Likewise, the marginal costs rise only slightly, except for the large increase in range grazing marginal cost.

Conclusions

Three major conclusions can be drawn from the foregoing analysis of resource interactions.

The first conclusion is that projecting renewable resource supplies requires an understanding of the complex interactions between the biological potential of the land to produce combinations of goods and services, the impact of various management strategies, and the motives of various types of landowners. At the present time, knowledge of these interactions is limited and should be the focus of increased attention from the forestry research community. The accuracy of any modeling efforts to quantify these resource interactions will be limited by the understanding of both the biology and economics of multiresource production.

A second conclusion is that a model has been developed which can be used to examine a large number of land areas of different productive capacity and to quantify the impacts of meeting increased demands for timber and range grazing. This effort not only lays the groundwork for a more sophisticated way to assess the capability of the Nation's forest and range lands to produce goods and services, but it also can be used to analyze in more detail the benefits and costs of particular management strategies as they are applied to particular regions of the country.

The third conclusion is that the Nation's forest and range lands have the productive capacity to meet the ever-increasing demands for nearly all renewable resource products through the next five decades. Though the inherent productive capacity is there, several changes in land management will have to occur. There will have to be more intensive management, which will require larger investments than are currently being made. There will have to be shifts among regions in the proportionate share of certain goods which they produce. There will have to be shifts in supply among ownerships with increasing share of goods and services being provided from private ownerships.

Chapter 9. — Scientific Information and Data Needs

Four major areas for which improvements in scientific information and data were needed to guide forest and range land policies and programs were identified in the 1975 Assessment of Renewable Resources.[1] These are:

- inventories of forest, range, and inland water resources.
- estimates of physical responses of forest, range, and inland waters to changes in management practices.
- surveys of the use of forest and range products.
- research on the techniques of collecting data and information needed for management purposes.

Progress Since 1975

Although the time since the 1975 Assessment has been too short for results of changes in research programs to be available, progress was made in at least three of the major areas identified above. Furthermore, the groundwork for future improvement has been established. Much remains to be done, however, to respond fully to the research needs identified in the 1975 Assessment for these and other areas.

Moreover, needs exist for research on associated problems involved in the administration, management, and use of forest and range lands. These are described in detail in a recent study of national research needs prepared by a Task Force of the U.S. Department of Agriculture and the National Association of State Universities and Land Grant Colleges.[2]

Inventories of Forest and Range Resources

Research on developing, testing, and evaluating new inventory techniques for obtaining needed information on renewable natural resources has been underway. One example is the recently completed South Carolina Multiresource Inventory Pilot Study conducted by the Renewable Resources Evaluation Unit of the Southeastern Forest Experiment Station.[3] This pilot study expands the timber inventory for South Carolina, which is conducted at regular intervals by the Forest Service, to include other renewable forest resources. The basic approach was to expand the existing timber inventory into a multiresource inventory by making maximum use of well-established inventory methods.

Additional data obtained at each sample location included special information needed for evaluating wildlife habitat, recreation use, range suitability, water quality, erosion hazards related to forestry practices, and the use-interactions associated with various forest conditions in South Carolina. The vegetative makeup of different forest conditions reflects the basic ecological relationships vital to multiresource evaluations. Consequently, a major goal of the pilot study was to quantify and describe all the vegetation at each sample location in relation to the observed uses of the forest land. Many of the data elements already being collected in the regular timber inventory also proved useful in assessing nontimber resources.

Analysis of the multiresource inventory data collection has not yet been completed. However, preliminary analyses show that the South Carolina pilot study met its planned objectives. It appears that, for the first time in any State, managers and policymakers have multiresource inventory data on a common statewide basis.

Another example of a new method for inventorying wildland resources is known as ECOSYM[4]. This is a comprehensive system for land classification and a framework for building a multiresource information system. It provides a framework of ecosystem components that are hierarchically structured and objectively defined. It includes systems for classifying bedrock geology, regolith topography, climate, soil, current vegetation, and potential vegetation. The ecosystem components are defined independently of their relation to adjacent components. Any component or combination of components can be used to classify areas for management purposes. Similarly, knowledge of the components and their interrelationships on any given area can be used, perhaps in combination with the other available information, to define appropriate rules for management of the land and vegetative resource. These rules, in turn, can be applied to the information on components, which are stored in computers, to provide land managers with processed information in either mapped or tabular form.

ECOSYM has been tested sufficiently to warrant considering it for adoption as a common conceptual approach to developing natural resource information systems. The component classifications have

[1] Forest Service, U.S. Department of Agriculture, The Nation's renewable resources — an assessment, 1975. For. Resource Rep. 21, U.S. Gov. Print. Off., Washington, D.C., 243 p., 1977.

[2] U.S. Department of Agriculture and the National Association of State Universities and Land Grant Colleges. National program of research for forests and associated rangelands. U.S. Department of Agriculture, Forest Service, Washington, D.C., 40 p., 1978.

[3] McClure, Joe P., N. D. Cost, and H. A. Knight. Multiresource inventories, a new concept for Forest Survey. Forest Service. U.S. Department of Agriculture. Research Paper SE. (In process).

[4] Henderson, J. A. and L. S. Davis. ECOSYM: a classification and information system for wildland resource management. *In* Integrated inventories of renewable natural resources: Proc. of workshop. U.S. Department of Agriculture, Forest Service, Rocky Mountain For. and Range Exp. Sta., p. 384-389. 1978.

proved practical in field tests and have provided a common basis for developing rules for predicting resource characteristics with acceptable accuracy. Although application of ECOSYM for management planning at the National Forest, regional, and national levels still needs to be tested, it is expected to be a useful resource inventory approach.

A related effort has been underway to develop a compatible land classification system for resource management agencies. To date, no compatible classification system or data base has emerged, either within or among natural resource agencies, from which data could be obtained without manipulation to a common denominator. The need for a compatible land classification system became even more acute with the passage of the Renewable Resources Planning Act. Renewable resource assessments must account for all the forest and range lands of the United States, its territories, and its possessions and must rely on data developed by the Forest Service and other agencies.

In response to this need, the Chief of the Forest Service created a task group in 1976 to recommend a land classification system to be used in these assessments. This group has recommended a component, rather than an integrated, system for uniform assessment inventories[5]. The four major components are vegetation, soil, landform, and water. In addition, climate is used as a criterion for separating the vegetation and soil components.

The purpose of the proposed system is to make possible the identification of land areas with similar characteristics and that respond similarly to management practices as constrained by environmental conditions. Adoption of this system, which has had input from many different Federal and State agencies and disciplines, promises to facilitate future assessments, by improving resource inventories and providing a basis for extending research results to evaluate management alternatives.

Important progress has also been made recently to help insure that data collected by the Federal agencies concerned with forest and range lands and their associated waters can be efficiently utilized in future national assessments. An interagency agreement between the Bureau of Land Management, Fish and Wildlife Service, Soil Conservation Service, Geological Survey, and Forest Service provides for liaison and cooperation in survey, inventory appraisal, assessment, and planning activities for renewable resources. It assures administrative action to minimize duplication and overlapping efforts and to enhance and encourage overall data collection, data storing, appraisal efficiency, and program compatibility. A similar agreement has also been developed between the Bureau of Indian Affairs and the Forest Service.

In addition, a liaison committee has been formed between the Forest Service and the Soil Conservation Service to assure coordination in inventory, monitoring, assessment, appraisal, and program activities.

In a related effort, a case study of forest and range land management planning has been underway to develop and demonstrate how the national assessment and Forest Service program can be linked to National Forest level plans.[6]

Evaluation of this case study indicates that the basic purposes of the project were met. National Forest planning within this framework will provide for refining, improving, and updating data bases developed in regional plans. This will result in an improved basis for developing future regional programs. However, techniques to aggregate data from the regional to the national level have not been fully developed. In addition, this project has illustrated the need to be able to deal with area or local resource unit data in order to be more sensitive to the various localized social and economic situations.

Physical Responses to Change in Management

One of the basic needs in improving the management of forest and range lands is information on the physical response to management programs. Information is particularly lacking to describe multiresource interactions, or the relationship among resources on a common area as management programs change. These are critical data needs for managers of forest and range lands who must know with reasonable certainty what effects their management decisions will have.

One recent effort to provide this kind of information was aimed at improving planning at the National Forest level and similar levels in other resource managing agencies.[7] It involved developing and testing up-to-date techniques for predicting the potential differences among alternative management programs. These techniques are now being tested on several National Forests in the West to determine if they can aid resource managers in making decisions.

This approach provides an assessment of both physical and social conditions through:

[5] Driscoll, R. S., J. W. Russell and Marvin C. Meier. Recommended national land classification system for renewable resource assessment. Unpub. rep. on file at the Rocky Mountain For. and Range Exp. Sta. 1978.

[6] Rocky Mountain Region, Forest Service, U.S. Department of Agriculture. Regional Planning Case Study. preliminary draft, July 17, 1978.

[7] Brown, Thomas C., Forest and range land management; an approach for local planning efforts. Unpublished report on file at the Rocky Mountain Forest and Range Exp. Sta. 17 p. 1978.

(1) public involvment.
(2) resource inventory and valuation studies.
(3) data evaluation.

This approach is intended to satisfy information needs at the local level and higher organizational levels where comparisons of program alternatives must be made.

Tools for quantifying some social effects are also being tested. These include techniques for quantifying estimates of quality, for assigning monetary values to market and some nonmarket products, and for estimating money flows, employment, and other local impacts.

The two keys to dealing with physical and resource use interactions are an understanding of ecology and having techniques to simulate and predict physical changes resulting from various management alternatives. ECOSYM, which was discussed earlier, provides an inventory technique for organizing resource information so that it can be used to simulate physical changes.

The procedures and tools being developed and tested in this effort should improve local level planning. This, in turn, should strengthen the linkage between national assessments and local level planning and decisionmaking.

Work is also underway in the Washington Office of the Forest Service to develop and test a model to estimate multiresource use interactions. It is expected that this model will make it possible to describe the complex relationships among forest and range land resource uses over time and space. In addition, it will be possible to assemble information on these interactions under alternative management strategies as a basis for future assessments.

Surveys of Product Use

In response to the needs for better information on the use of forest and range land products that were identified in the 1975 Assessment, the Forest Service expanded its National Timber Requirements Program and centralized this program at the Forest Products Laboratory at Madison, Wis. Some progress has been made in getting new information on wood used in housing and nonresidential construction, highway construction, farm structures, and mobile homes. An update on wood used in manufacturing from the previous 1965 report is also underway in collaboration with the Washington Office and the Forestry Services Laboratory at Princeton, W. Va.

Development of a model for estimating demand for timber products is now well underway. This will provide a means of rapidly preparing alternative estimates of timber demand.

With respect to wildlife, nationwide computerized data banks have been constructed for each timber type and range type within each State. Included are:

1. Complete lists of resident and common migrant vertebrate and selected invertebrate species.
2. Identification of species listed as threatened or endangered by the Federal or State governments, those species that are sensitive to standard land and water management practices, and those species of recreational and commercial importance.
3. The generalized habitat requirement of each species expressed in terms of data compiled in timber (size class) and range (condition class) inventories, to the extent possible.

The data base also includes information provided by the Fish and Wildlife agencies of each State concerning the consumptive uses and harvest and population levels of individual species, from the mid-1950's to the mid-1980's.

As a result of this work, management-level information has increased dramatically in terms of quantity and quality of data. Perhaps the most significant gain has been due to computerizing this information so that it is more readily available to land and water managers.

A nationwide outdoor recreation survey of private owners of forest and range land has been completed. It describes the private sector resources, owner motivation, and recreation supply potential. This survey provides, for the first time, a measure of the existing nationwide recreation resource supply on forest and range lands of the private sector by region, the availability of forest and range lands for general public recreational use by region, and assesses existing and desired recreation-supply relationships between the public and private sector. This survey also complements the recently completed inventory of recreation enterprises conducted by the National Association of Conservation Districts.

Improving Techniques for Data Collection

In addition to the information needs, there is a related need to develop techniques for collecting information on forest and range land resources. Progress has been made in this area, although some of the results must still be tested. The ECOSYM approach is intended to provide a method for classifying basic land resources which could be used as a framework for data collection. The South Carolina

multiresource inventory pilot project also provides a framework for data collection, in this case one based on the regular timber inventory and classifications.

Two other projects have been directed more specifically at improving data collection techniques within an overall land and resource classification system. One such project, the Susitna Area Inventory in the Susitna Valley, Alaska, is a cooperative venture with the Soil Conservation Service. It is designed as an in-place (mapping) inventory to obtain accurate estimates of total vegetative cover at a level of sampling below that used in the normal forest inventories.

The second project for testing different sampling designs and measurement procedures for getting multipurpose resource data is a cooperative inventory program in Grand County, Colo. which is testing an improved systematic sampling design.

Data on soil series, density, foliar cover, current production, plant height, and form and age class of shrubs are obtained at each sample location. In a followup effort, these data will be stratified into various vegetation-soil units within which different vegetation-soil-landform-water parameters will be sampled.

Continuing Needs

Progress has been made in meeting some of the scientific information and data needs identified in the Assessment of Renewable Resources, 1975. However, the basic thrust of the information and data needs section of the 1975 Assessment is still relevant for planning purposes today. Some highlights are listed below:

Inventories of Forest and Range Resources

The need continues to accelerate and intensify the present surveys of renewable resources of forest and range lands. With respect to the surveys of timber resources, the present time between successive State inventories averages 12 years. This is far too long to adequately monitor the changes taking place in timber resources. In some States where industrial development has been rapid, timber removals have changed by as much as 40 percent in a 10-year period. In other areas such as the Delta region of Arkansas, Louisiana, and Mississippi, forest land has been cleared at a rate of more than 300,000 acres a year. Obviously, where such fast changes are taking place, inventory cycles of more than 5 years are of limited usefulness in guiding resource planning and management.

The survey should also be intensified to provide more precise local resource data. Present sampling standards are designed to achieve acceptable sampling errors for large areas of forest land (1 million acres) or for relatively large timber volumes (1 billion cubic feet of timber). This limits the usefulness of the data for local governments, planning agencies, and resource industries, who may need statistically reliable information for relatively small geographic areas. Intensifying the inventories to provide this information would aid local land use planning and management of forest lands, including those in small private ownerships.

Basic surveys of rangeland resources are also needed, including forage for domestic livestock and other uses of rangelands. A foundation for such inventories is being laid in the work described above on multiresource inventories, but a systematic inventory to national standards is needed.

Information available on the Nation's outdoor recreation resources has been collected for specific studies or management needs and is of limited use in guiding recreation management on forest and range lands. A systematic, continuing inventory with national standards is needed for recreation resources. This survey should include an inventory of the forest and range land available and suitable for outdoor recreation.

Responsibilities for inventorying wildlife populations are spread among various States and Federal agencies. There is a need to standardize data for national assessments, to improve the data base for nongame species of wildlife, and to provide better information relating wildlife populations to the forest, range, and water base.

The classification approaches described may satisfy the need for a land classification system that is a prerequisite to useful data collection for planning purposes. However, additional evaluation of this and other possible approaches is necessary. In addition, very little work has been done on aquatic systems, and there are no operational classification systems for lakes, streams, and marshes. A good classification system is the foundation for any useful inventory and is needed for both land and water resources.

Physical Responses of Resources to Management Practices

Information on physical responses of forest and range land and the associated waters to management practices is still inadequate and especially so for multiresource interactions. The effort now going into describing and measuring the responses of these resources to management practices must be greatly expanded to provide the information necessary for efficient administration and management of forest and range lands.

Surveys of Use of Forest and Range Land Products

As indicated above, there has been some progress in obtaining data on timber products use in various markets. However, this is limited in relation to the need. Thus, there is still some urgency in expanding and accelerating the ongoing survey work to obtain current data on timber products consumption in all important end uses. In view of the rapid changes in population, economic activity, technologies, and prices of substitute products and energy, it is also necessary to repeat the surveys at intervals short enough to insure that all significant changes in use can be identified, analyzed, and evaluated.

Progress has been limited in collecting additional data on outdoor recreation, including the various activities based on the wildlife and fish resources. There is a need to collect such information on a continuing basis, utilizing a standardized reporting system that permits the aggregation of the data to any desirable geographic level.

With regard to wildlife, the first need is to ensure that what is known about wildlife and fish is compiled, validated, and made available in a usable form to land and water managers. This summary includes information on the consequences to wildlife and fish species of alternative actions, the possible tradeoffs between fauna and other resources, and the economic and social implications to people of the alternatives.

Further work that leads to a fuller understanding of the determinants of population levels is also necessary. Because no direct quantitative inventory of wildlife or fish habitats exists for any substantial part of the Nation, it is important to determine how data that have already been collected in timber, range, and water inventories can be used as surrogate measures of habitats. For the more distant future, expanding such inventories to directly measure critical elements of habitats is necessary.

Techniques of Collecting Data for Management Purposes

The major challenge in developing techniques to improve the collection of data for management purposes continues to be, as it was in 1975, in developing statistically reliable sampling techniques for estimating nontimber resources and in linking these estimates to comprehensive land classification systems. Sampling procedures for multiresource inventories done source surveys, but not in surveying other resources. In addition, little is known about the kinds of sampling procedures for multiresources inventories done simultaneously across resources sytems, either for local or for national use.

Progress has been limited since 1975 in improving techniques for inventorying nontimber resources. An increased effort in this area is still needed. A timber inventory technique that maintains continuity and reliability of inventories over time exploits the relationship between successive surveys through a technique termed "sampling with partial replacement." Additional research is needed to develop this or alternative techniques for the other resource systems, and to determine the time interval and the sample replacement policy that would be best for simultaneous sampling of all resources.

Other Data Needs

Limited progress has been made in several other areas of need identified in the 1975 Assessment. Better information is still needed on the cost of various management practices, both for such commodity resources as timber and forage and for such noncommodity resources as wildlife habitat. At the same time, better information is needed on the prices of forest and range land outputs that do have established markets and on values of other resources.

About a dozen States now publish periodic reports (quarterly, semiannual or annual) on prices of stumpage (standing timber) and important primary products such as sawlogs, veneer logs, pulpwood, and posts. Data on the average stumpage prices of standing timber sold from the National Forests by major species and region are published on a quarterly basis by the Forest Service. However, because of limited geographic coverage and deficiencies in frequency and accuracy, the published data are generally not adequate for timber owners and forest land managers.

The value of timber and forage resources can at least be estimated on the basis of some market evidence. But relating such values to the values of other resources of forest and range lands has always been difficult. Research is still needed to develop better ways to measure the output of the recreation and wilderness resource systems and to provide reasonable estimates of the value of these resources.

Methods for projecting supplies of forest, range, and inland water products are primitive. For some products—such as outdoor recreation, hunting, and fishing—there is little information on current supplies and no operational techniques for assessing either shortrun or longrun supply trends. More work is required on methods and techniques for projecting supplies and the response to alternate levels of management, particularly for such major products as timber.

Defining economic, social, and environmental goals and using them to guide public programs is difficult and far from an exact science. Decisions on the management and use of renewable resources, however, unavoidably imply that such goals have been determined. The development of ways to translate general societal goals into specific resource management objectives is an important area for long term research. One technique now being widely used is public participation in management decisions, but the most effective ways of getting and incorporating public participation have yet to be identified and documented.

As work progressed on the Assessment, another related need has become more and more evident. That need is to study and quantify the social, economic, and environmental implications of the general demand-supply outlook for most renewable resources of forest and range lands, i.e., an outlook in which the demands for most products are rising more rapidly than supplies. This kind of information is a basic need—it is the societal basis for changing policies and programs. The results are likely to have profound impacts on the future management and use of forest and range lands.

Glossary

Aggregated subarea — Subdelineations of water resource regions — also based upon hydrologic boundaries.

Animal unit months (AUM'S) — Amount of grazing required by a 1,000 pound cow for 1 month.

Biological potential — The amount of living matter potentially producible by the unit being discussed without fertilization or irrigation.

Bureau of Land Management land — Federal lands administered by the Bureau of Land Management, U.S. Department of the Interior.

Commercial forest land — See commercial timberland.

Commercial species — Tree species suitable for industrial wood products.

Commercial timberland — Forest land which is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as commercial timberland have the capability of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently, inaccessible and inoperable areas are included.)

Consumptive water use — Portion of water withdrawn that is consumed through evaporation, transpiration, or discharge into irretrievable locations.

Cord — A pile of stacked wood containing 128 cubic feet within its outside surfaces. The standard dimensions are 4 by 4 by 8 feet.

Cropland — Land under cultivation within the past 24 months, including cropland harvested, crop failures, cultivated summer fallow, idle cropland used only for pasture, orchards and land in soil improving crops, but excluding land cultivated in developing improved pasture.

Cull trees — Live trees of sawtimber and poletimber size that are unmerchantable for saw logs now or prospectively because of roughness, rot, or species (also see rotten cull trees and rough trees).

Deferred forest land — National Forest lands that meet productivity standards for commercial forest, but are under study for possible inclusion in the Wilderness System.

Depletion — The utilization of a natural renewable resource at a rate greater than the rate of replenishment.

Developed (or concentrated) recreation — Outdoor recreation requiring significant capital investment in facilities to handle a concentration of visitors on a relatively small area.

Diameter classes — A classification of trees based on diameter of outside bark measured at breast height (4½ feet above the ground). D.b.h. is the common abbreviation for "diameter at breast height." When using 2-inch diameter classes the 6-inch class, for example, includes trees 5.0 through 6.9 inches d.b.h. inclusive.

Dispersed recreation — Outdoor recreation in which visitors are diffused over relatively large areas. Where facilities or developments are provided, they are more for access and protection of the environment than for the comfort or convenience of the people.

Domestic water use — Water used for drinking, sanitation, street flushing, fire protection, and lawn and garden irrigation.

Ecosystem — A complete, interacting system of organisms considered together with their environment, e.g., a marsh, a watershed, a lake, etc.

Endangered species — Any species of animal or plant which is in danger of extinction throughout all or a significant portion of its range.

Establishment — An economic unit, generally at a single physical location, where business is conducted or where services or industrial operations are performed.

Farmer and other private — All private ownerships except industry.

Farmer-owned lands — Lands owned by a person who operates a farm, either doing the work himself or directly supervising the work.

Forest industry lands — Lands owned by companies or individuals operating wood-using plants.

Forest land — Land at least 10 percent stocked by forest trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. (Also see Commercial forest land, Productive-reserved forest land, and Other forest land.) Forest land includes transition zones, such as areas between heavily forested and non-forested lands that are at least 10 percent stocked with forest trees, and forest areas adjacent to urban and built-up lands. Also included are pinyon-juniper and chaparral areas in the West, and afforested areas. The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if less than 120 feet in width.

Forest site productivity class — A classification of forest land in terms of potential cubic-foot volume growth per acre at culmination of mean annual increment in fully stocked natural stands.

Forest types — A classification of forest land based upon the tree species presently forming a plurality of stocking. For poletimber size trees and larger, stocking is determined from basal area occurrence and for trees less than 5.0 inches d.b.h. from number of trees.

Major eastern forest type groups:

White-red-jack pine — Forests in which eastern white pine, red pine, or jack pine, singly or in combination, comprise a plurality of the stocking. (Common associates include hemlock, aspen, birch, and maple.)

Spruce-fir — Forests in which spruce or true firs, singly or in combination, comprise a plurality of the stocking. (Common associates include white-cedar, tamarack, maple, birch, and hemlock.)

Longleaf-slash pine — Forests in which longleaf or slash pine, singly or in combination, comprise a plurality of the stocking. (Common associates include other southern pines, oak, and gum.)

Loblolly-shortleaf pine — Forests in which loblolly pine, shortleaf pine, or southern yellow pines except longleaf or slash pine, singly or in combination, comprise a plurality of the stocking. (Common associates include oak, hickory, and gum.)

Oak-pine — Forests in which hardwoods (usually upland oaks) comprise a plurality of the stocking but in which southern pines comprise 25-50 percent of the stocking. (Common associates include hickory and yellow-poplar.)

Oak-hickory — Forests in which upland oaks, or hickory, singly or in combination, comprise a plurality of the stocking except where pines comprise 25-50 percent, in which case the stand would be classified as oak-pine. (Common associates include yellow-poplar, elm, maple, and black walnut.)

Oak-gum-cypress — Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, comprise a plurality of the stocking except where pines comprise 25-50 percent, in which case the stand would be classified as oak-pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)

Elm-ash-cottonwood — Forests in which elm, ash, or cottonwood, singly or in combination, comprise a plurality of the stocking. (Common associates include willow, sycamore, beech, and maple.)

Aspen-birch — Forests in which aspen, balsam poplar, paper birch, or gray birch, singly or in combination, comprise a plurality of the stocking. (Common associates include maple and balsam fir.)

Major western forest type groups:

Douglas-fir — Forests in which Douglas-fir comprise a plurality of the stocking. (Common associates include western hemlock, western redcedar, the true firs, redwood, ponderosa pine, and larch.)

Hemlock-Sitka spruce — Forests in which western hemlock and/or Sitka spruce comprise a plurality of the stocking. (Common associates include Douglas-fir, silver fir, and western redcedar.)

Redwood — Forests in which redwood comprises a plurality of the stocking. (Common associates include Douglas-fir, grand fir, and tanoak.)

Ponderosa pine — Forests in which ponderosa pine comprises a plurality of the stocking. (Common associates include Jeffery pine, sugar pine, limber pine, Apache pine, Chihuahua pine, Douglas-fir, incense-cedar, and white fir.)

Western white pine — Forests in which western pine comprises a plurality of the stocking. (Common associates include western redcedar, larch, white fir, Douglas-fir, lodgepole pine, and Engelmann spruce.)

Lodgepole pine — Forests in which lodgepole pine comprises a plurality of the stocking. (Common associates are alpine fir, western white pine, Engelmann spruce, aspen, and larch.)

Larch — Forests in which western larch comprises a plurality of the stocking. (Common associates are Douglas-fir, grand fir, western redcedar, and western white pine.)

Fir-spruce — Forests in which true firs (Abies spp.), Engelmann spruce, or Colorado blue spruce, singly or in combination, comprise a plurality of the stocking. (Common associates are mountain hemlock and lodgepole pine.)

Hardwoods — Forests in which aspen, red alder or other western hardwoods, singly or in combination, comprise a plurality of the stocking.

Chaparral — Forests of heavily branched dwarfed trees or shrubs, usually evergreen, the crown canopy of which at maturity covers more than 50 percent of the ground and whose primary value is watershed protection. The more common chaparral constituents are species of *Quercus, Cercocarpus, Garrya, Ceanothus, Arctostaphylos,* and *Adenostoma.* (Types dominated by such shrubs as *Artemisia, Chrysothamnus, Purshia, Gutierrezia,* or semi-desert species are not commonly considered chaparral.)

Pinyon-juniper — Forests in which pinyon pine and/or juniper comprise a plurality of the stocking.

Growing stock trees — Live sawtimber trees, poletimber trees, saplings, and seedlings meeting specified standards of quality or vigor; excludes cull trees.

Growing stock volume — Net volume in cubic feet of live sawtimber and poletimber trees from stump to a minimum 4-inch top (of central stem) outside bark or to the point where the central stem breaks into limbs.

Growth — See definition for "net annual growth."

Hardwoods — Dicotyledonous trees, usually broad-leaved and deciduous.

Indian lands — Tribal lands held in fee by the Federal Government but administered for Indian tribal groups and Indian trust allotments.

Industrial wood — All commercial roundwood products except fuelwood.

Inland waters — Lakes, reservoirs, and ponds over 2 acres in size and all waterways.

Land area — The area of dry land and land temporarily or partially covered by water such as marshes, swamps, and river flood plains (omitting tidal flats below mean high tide); streams, sloughs, estuaries, and canals less than 1/8 of a statute mile in width; and lakes, reservoirs, and ponds less than 40 acres in area.

Logging residues — The unused portions of poletimber and sawtimber trees cut or killed by logging.

Mortality — The volume of sound wood in live trees that have died from natural causes during a specified period.

National Forest System land — Federal lands which have been designated by Executive Order or statute as National Forests or purchase units, and other lands under the administration of the Forest Service including experimental areas and Bankhead-Jones Title III lands.

Net annual growth — The net increase in the volume of trees during a specified year. Components of net annual growth include the increment in net volume of trees at the beginning of the specific year surviving to its end, plus the net volume of trees reaching the minimum size class during the year, minus the volume of trees that died during the year, and minus the net volume of trees that became rough or rotten trees during the year.

Net volume in board feet — The gross board-foot volume of trees less deductions for rot or other defect affecting use for lumber.

Net volume in cubic feet — Gross volume in cubic feet less deductions for rot, roughness, and poor form. Volume is computed for the central stem from a 1-foot stump to a minimum 4.0-inch top diameter outside bark, or to the point where the central stem breaks into limbs.

Noncommercial species — Tree species of typical small size, poor form, or inferior quality which normally do not develop into trees suitable for industrial wood products.

Nonforest land — Land that has never supported forests and lands formerly forested where use for timber management is precluded by development for other uses. (Note: Includes areas used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining clearings, powerline clearings of any width, and 1- to 40-acre areas of water classified by the Bureau of the Census as nonforest land. If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet wide, and clearings, etc., more than 1 acre in size, to qualify as nonforest land.)

Nonpoint pollution sources — Those sources of pollution that are diffuse in both origin and in time and points of discharge, and depend heavily on weather conditions such as rainstorms or snowmelt. Pollutants can originate on natural source areas as well as areas affected by man's activities.

Off-road vehicles (ORV's) — Vehicles such as motorcycles, all-terrain vehicles, fourwheel drives, and snowmobiles.

Other Federal land — Federal land other than lands administered by the Forest Service or the Bureau of Land Management.

Other forest Land — Forest land incapable of producing 20 cubic feet per acre of industrial wood under natural conditions because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness.

Other land — All land area other than forest and range land.

Other private land — Privately owned land other than forest industry or farmer-owned.

Other public land — Publicly owned land other than National Forest System lands.

Other removals — The net volume of growing-stock trees removed from the inventory by cultural operations such as timber-stand improvement, by land clearing, and by changes in land use such as a shift to wilderness.

Ownership — The property owned by one owner, including all parcels of land in the United States.

Pasture — Land which is currently improved for grazing by cultivation, seeding, fertilization, or irrigation.

Phreatophyte — A deep-rooted plant which obtains its water from the water table or the layer of soil just above it.

Plant residues — Wood materials from primary manufacturing plants that are not used for any product. Typically includes slabs, edgings, trimmings, miscuts, sawdust, shavings, veneer cores and clippings, and pulp screenings.

Point pollution source — Any discernible, confined, and discrete conveyance from which pollutants are or may be discharged, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft.

Poletimber stands — Stands at least 10 percent stocked with growing stock trees, of which half or more of the stocking is sawtimber and/or poletimber trees with poletimber stocking exceeding that of sawtimber. (See definition of Stocking.)

Poletimber trees — Live trees of commercial species at least 5.0 inches in diameter at breast height but smaller than sawtimber size, and of good form and vigor.

Potential growth — The average net annual growth per acre attainable in fully stocked natural stands at culmination of mean annual growth of dominate or codominate trees.

Primary manufacturing plants — Plants using round wood products such as saw logs, pulpwood bolts, veneer, logs, etc.

Productive-reserved forest land — Productive public forest land withdrawn from timber utilization through statute or administrative regulations.

Productivity class — A classification of forest land in terms of potential growth in cubic feet of fully stocked natural stands.

Range — All land producing native forage for animal consumption, and lands that are revegetated naturally or artificially to provide a forage cover that is managed like native vegetation.

Rangeland — Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs, including land revegetated naturally or artificially that is managed like native vegetation. Rangeland includes natural grasslands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows that are less than 10 percent stocked with forest trees of any size.

Major rangeland type groups:

Sagebrush — Rangeland characterized by shrubs, principally of the genus *Artemisia,* which are usually 1 to 7 feet high, although other shrubs may be part of the vegetation. Grasses of the genera *Agropyron, Festuca, Stipa, Poa,* and *Bromus,* as well as broad-leaved herbs, may be in the understory.

Desert shrub — Rangeland characterized by dryland (xeric) shrubs varying in height from 4 inches to many feet. Principal shrubs are blackbush, saltbush, greasewood, creosote bush, bur sage, palo verde, and cactus. Stands are generally open, with a large amount of bare soil and desert pavement exposed. Understory vegetation is generally sparse.

Shinnery — Midgrass prairie with open to dense stands or broad-leaved deciduous shrubs and occasional needle-leaved low trees and shrubs. The major shrubs are Harvard and shin oak, juniper, and mesquite. Common associates include little bluestem, side-oats grama, sand bluestem, sand sagebrush, and yucca.

Texas savanna — A high-shrub savanna characterized by a dense to very open mixture of broad-leaved, deciduous and evergreen low trees and shrubs and needle-leaved low evergreen trees and shrubs. The grass varies from short to medium tall, and the herbaceous vegetation varies from dense to open. Common plants include mesquite, acacia, oaks, juniper, ceniza, cactus, bluestems, three-awns, buffalo grass, gramas, and tobosa.

Southwestern shrubsteppe — Rangeland characterized by vegetation types ranging from short grass with scattered shrubs to shrubs with scattered areas of short grasses. Characteristic vegetation includes yucca, mesquite, creosotebush, tarbush, black grama, three-awns, tobosa, side-oats grama, and curly mesquite.

Mountain grasslands — Rangeland characterized by bunchgrass of the fescue and wheatgrass, oatgrass, bluegrass, and needlegrass groups. Forbs may be abundant.

Mountain meadows — Rangeland characterized by mesic grasses such as hairgrass, red top, and bent grasses; sedges; rushes; and in some cases, phreatophytic shrubs. Under the best conditions, 70 percent of the ground is covered by vegetation, more than three-fourths of which may be perennial grasses. Sedges may constitute as much as 15 percent of the cover. Perennial forbs with showy flowers make up only about 10 percent of the cover.

Plains grasslands — Rangeland characterized by short, warm season grasses, with a minor interspersion of forbs and shrubs. Dominant vegetation includes blue grama and buffalo

grass, or western wheatgrass and needlegrass. Occasional shrubs include juniper, silver sagebrush, silver buffaloberry, skunkbush sumac, rabbitbrush, and mesquite.

Prairie — Rangeland characterized by the tall grasses, bluestems constituting about 70 percent of the vegetation. Large numbers of flowering forbs are present but are usually overshadowed by the grasses. Woody vegetation is rare.

Desert grasslands — Rangeland with grasses predominant on plateaus at intermediate elevations, and shrubs predominate at higher and lower elevations. Important grasses are galleta, black grama, tobasa, and three-awn.

Wet grasslands — Rangeland characterized by vegetation forming a medium-tall to very tall, usually dense grassland, consisting of cordgrasses, wiregrass, or sawgrass. Includes marshes dominated by tule, bulrush, cattail, or soft flag. There may be scattered palms, shrubs, and low to medium-tall broadleaved evergreen trees and shrubs.

Annual grasslands — Rangeland characterized by annual grasses, such as wild oats, brome, wild barley, and fescue. Forbs are numerous and filaree is the most important.

Alpine — Rangelands dominated by grasses, woodrush, and sedges of rather low stature, but with a large number of associated forbs. Common grasses are bentgrass, hairgrass, mountain timothy, bluegrasses, and spike tristetum. Dwarf willow occurs, in some places, on the moist soils of protected slopes and valleys.

Recreation visitor day — Twelve visitor hours, which may be aggregated continuously, intermittently, or simultaneously by one or more persons.

Removals — The net volume of growing stock or sawtimber trees removed from the inventory by harvesting; cultural operations, such as timber stand improvement; land clearing; or changes in land use.

Residues

Coarse residues — Plant residues suitable for chipping, such as slabs, edgings, and ends.

Fine residues — Plant residues not suitable for chipping such as sawdust, shavings, and veneer clippings.

Plant residues — Wood materials from primary manufacturing plants that are not used for any product.

Logging residues — The unused portions of sawtimber and poletimber trees cut or killed by logging.

Urban residues — Wood materials from urban areas, such as newspapers, lumber, and plywood from building demolition, and used packaging and shipping wood materials.

Rotten cull trees — Live trees of commercial species that do not contain a saw log now or prospectively, primarily because of rot (e.g., when rot accounts for more than 50 percent of the total cull volume.)

Rough trees — (a) Live trees of commercial species that do not contain at least one 12-foot saw log, or two noncontiguous saw logs, each 8 feet or longer, now or prospectively, primarily because of roughness, poor form, splits, and cracks, and with less than one-third of the gross tree volume in sound material; and (b) all live trees of noncommercial species.

Roundwood equivalent — The volume of logs or other round products required to produce the lumber, plywood, woodpulp, paper, or other similar products.

Roundwood logs — Logs, bolts, or other round sections cut from trees.

Salvable dead trees — Standing or down dead trees that are considered currently or potentially merchantable by regional standards.

Sampling error — An expression of the degree of confidence that can be placed on an estimated total or average obtained by statistical sampling methods. Sampling errors do not include technique errors that could occur in photo classification of areas, measurement of volume, or compilation of data.

Saplings — Live trees of commercial species 1.0 inch to 5.0 inches in diameter at breast height and of good form and vigor.

Saw log — A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight, and with a minimum diameter inside bark for softwoods of 6 inches (8 inches for hardwoods) or other combinations of size and defect specified by regional standards.

Saw log portion — That part of the bole of sawtimber trees between the stump and the saw log top.

Saw log top — The point on the bole of sawtimber trees above which a saw log cannot be produced. The minimum saw log top is 7.0 inches d.o.b. for softwoods, and 9.0 inches d.o.b. for hardwoods.

Sawtimber stands — Stands at least 10 percent occupied with growing-stock trees, with half or more of total stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

Sawtimber trees — Live trees of commercial species containing at least one 12-foot saw log or two noncontiguous 8-foot logs, and meeting regional specifications for freedom from defect. Softwood trees must be at least 9 inches in diameter and hardwood trees 11 inches in diameter at breast height.

Sawtimber volume — Net volume of the saw log portion of live sawtimber trees in board feet.

Scenic rivers — Rivers or sections of rivers free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

Seedlings — Established live trees of commercial species less than 1.0 inch in diameter at breast height and of good form and vigor.

Seedling and sapling stands — Stands at least 10 percent occupied with growing-stock trees of which more than half of the stocking is saplings and/or seedlings.

Softwoods — Coniferous trees, usually evergreen, having needles or scalelike leaves.

Sound cull trees — (Rough trees) Live trees that do not contain a saw log now or prospectively, primarily because of roughness, poor form, or noncommercial species.

Special interest areas — Areas described in the Environmental Policy Act of 1970 which include (1) cultural areas — historic or prehistoric sites and places of obvious future historical value, and (2) natural areas — outstanding examples of the Nation's geological and ecological features.

Stand improvement — Measures such as thinning, pruning, release cutting, girdling, weeding, or poisoning of unwanted trees aimed at improving growing conditions for the remaining trees.

Stand-size classes — A classification of forest land based on the predominant size of timber present, that is, sawtimber, poletimber, or seedlings and saplings.

State, county, and municipal land — Land owned by States, counties, and local public agencies, or lands leased by these governmental units for more than 50 years.

Stocking — The degree of occupancy of land by trees, measured by basal area and/or number of trees by size and spacing, compared to a stocking standard, i.e., the basal area and/or number of trees required to fully utilize the growth potential of the land.

Threatened species — Any species of animal or plant which is likely to become an endangered species within the foreseeable future throughout all or a portion of its range.

Upper-stem portion — That part of the main stem or fork of sawtimber trees above the saw log top to a minimum top diameter of 4.0 inches outside bark or to the point where the main stem or fork breaks into limbs.

Urban and other areas — Areas within the legal boundaries of cities and towns; suburban areas developed for residential, industrial, or recreational purposes; school yards; cemeteries; roads; railroads; airports; beaches; powerlines and other rights-of-way; or other nonforest land not included in any other specified land use class.

Water resource region — The 21 major hydrologic regions into which the United States is delineated.

Wild rivers — Those rivers or sections of rivers free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive (and waters unpolluted).

Wilderness — An area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least 5,000 acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value (from Wilderness Act 1964).

Withdrawal use — Water that is taken from a source, used, and then returned to a source for reuse.

Tables

Multiple Resource Interactions

Index

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